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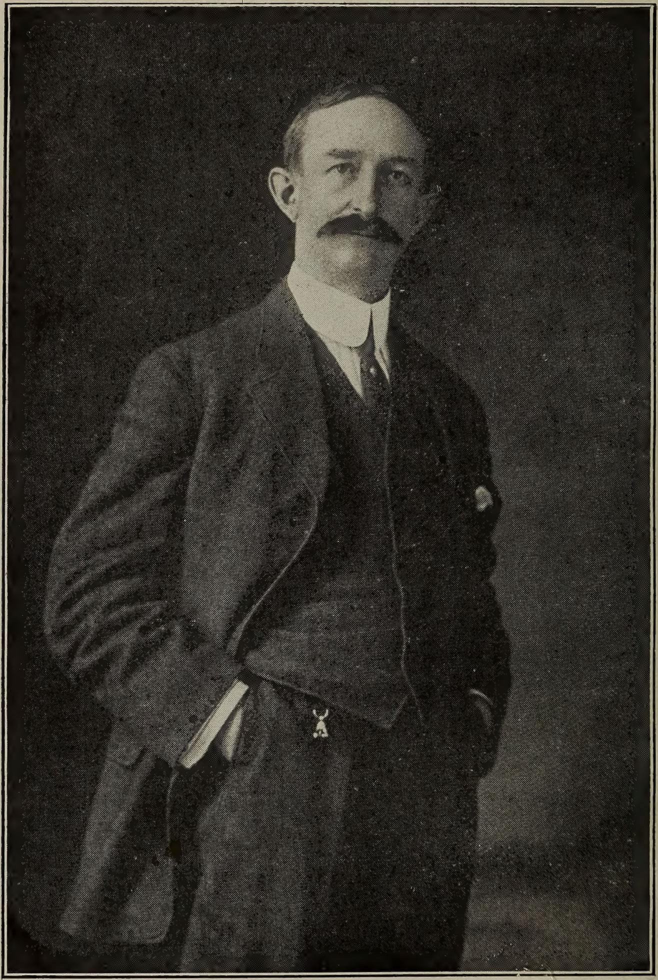
APPLIED SCIENCE

A good deal of consideration is being given this journal by its publishers, the Engineering Society, relative to its publication monthly throughout the entire year. The many points under discussion appear to be almost unanimously in favor of the twelve-issues-per-year proposal, and in all probability the next issue will announce its adoption.

We would like to have as many graduates as possible air their views upon the question, and will appreciate every opinion they take the trouble to submit.



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Applied Science

INCORPORATED WITH

TRANSACTIONS OF THE UNIVERSITY OF TORONTO ENGINEERING SOCIETY

Old Series Vol. 24 FEBRUARY, 1912 New Series Vol. V, No. 4

PROFESSOR GEORGE A. GUESS

The new Professor of Metallurgy is a graduate of Queen's University, M.A., 1904. He took the honor chemistry and science course, and also took a course in the School of Mining. His early work was in British Columbia, in various subordinate positions. He left a position in the Trail smelter to go to Colorado, where he spent a year in the San Juan district. He was for two years or more with the Greene Cananea Company, in Mexico, getting a wide variety of metallurgical experience in various investigations in those extensive works. From here he went to the Tennessee Copper Company, as assistant, and was soon after, raised to the position of metallurgical superintendent. After four years in Tennessee he went to the Cerro de Pasco Mining Co., in Peru, as metallurgical superintendent and assistant general superintendent. The smelter was situated at an altitude of 14,000 feet. Mrs. Guess could not live at this altitude and Mr. Guess returned to the States towards the end of last year, when the authorities of the University of Toronto, who for six months had been seeking both in America and in Europe for a man for the position of Professor of Metallurgy, were fortunate in securing his services. He has always been a deep student of his subject and an occasional writer for the technical press. His work has been marked by originality and conspicuous success on a very large scale.

The capacity of the Tennessee Copper Co.'s smelter was 40,000 tons of ore per month. It had for years been a school for metallurgists seeking information on pyritic smelting. When Mr. Guess took charge, he modified considerably the practice, making material reduction in working costs. The monthly output at the Cerro de Pasco was 4,000,000 lbs. of copper, besides silver. He has visited and studied most of the large metallurgical plants in America. He will be a very valued acquisition to the Engineering Faculty and to the mineral industry of Ontario. In welcoming him to the University, "Applied Science" would endorse the warm and enthusiastic reception tendered at the Engineering Society dinner, and wish him the measure of success in academic work that he has achieved throughout the length and breadth of the profession he follows.

RECENT DEVELOPMENTS IN ELECTRIC IRON SMELTING

By Thomas D. Robertson, M. Met.

Before considering in detail the newest process for the manufacture of pig iron from its ores on a large scale, it may be well to consider some of the features of the older and more generally employed process, namely, blast furnace smelting. As is well known the iron ore to be smelted is mixed with fuel, usually in the form of coke, and a certain amount of limestone, the latter being for the purpose of fluxing the earthy material of the ore and producing a fluid slag, which can be removed from time to time. By the action of the carbon in the coke upon the oxide of iron in the iron ore, metallic iron is produced, and owing to the heat supplied by the combustion of the fuel with the blast of hot air blown into the furnace the reduced iron melts and collects in the furnace bottom, being tapped off at suitable intervals.

The action of the coke is two-fold: About one-third of the carbon supplied is used up in uniting with the oxygen of the iron ore and thus accomplishing its reduction, whilst the other two-thirds is burnt by the oxygen of the air blast to produce sufficient heat to enable the various reactions to take place. In common practice rather more than one ton of fuel is used for every ton of pig iron produced, and not only must this fuel be of a high grade chemically, but it must possess mechanical strength and sufficient porosity.

The electric furnace has been used for a number of years now in the reduction of certain metals and in chemical processes, but it is only comparatively recently that it has become possible for electricity to be economically used in the production of the commonest of all metals, namely, pig iron. The electric furnace, however, was successfully used on quite a large scale for the production of steel, before it was applied with any measure of success to the reduction of iron ores.

The large amount of fuel, and incidentally fuel of very special quality, which is necessary to smelt iron ores in the blast furnace, has had an important effect upon the iron industries of those countries which were unfavorably situated with regard to their fuel supplies. Canada is one of those countries, and as it is only in the extreme East and West that coal has been found which will give a coke suitable for blast furnace smelting, furnaces operating in central Canada have perforce to use coke imported from the United States. Now, it was calculated that the electric furnace would dispense with two-thirds of the fuel required in the blast furnace, substituting electrically produced heat, for the heat chemically produced by the burning of this portion of the fuel, the other one-third of the fuel necessary for the reduction of the iron ore being employed in the electric furnace in the same manner as in the blast furnace. It seemed, therefore, that if electrically produced heat could be successfully substituted for the heat obtained from the burning of expensive fuel a saving in cost would be effected, and with this object in view the Dominion Government of Canada, in 1904, appointed a commission to visit the various electric furnaces in operation in the iron and steel plants of Europe. The result of this work was embodied in an exhaustive report, which showed in general, that whilst furnaces were working successfully on a commercial scale in the manufacture of certain grades of steel, electric smelting of iron ores was as yet in its infancy. As it was this latter branch of the subject which was of most interest to Canada, the Dominion Government decided to build an electric furnace, under the supervision of the Department of Mines, and carry out a series of trials with the object of deciding whether the electric furnace was suited to the treatment of the various Canadian ores, and whether it seemed probable that the process would be commercially successful when carried out on a larger scale. A furnace was built in 1905 at Sault Ste. Marie, and operated successfully, its scope being limited by its size and by certain features of its design. The publication of the results obtained, however, aroused more interest in Europe, particularly in Sweden, than they did in Canada. Sweden, having no domestic coal suitable for smelting, has always used charcoal for blast furnaces. Owing to the rapid growth of the wood pulp industry, and consequently increased demand for wood, the price of charcoal has steadily risen, so, in view of the fact that the fuel problem was becoming acute, three Swedish engineers, Assar Gronwall, Axel Lindblad, and Otto Stalhane, formed a company, called the Aktiebolaget Elektrometall, in order to design and build an electric furnace which would be capable of producing pig iron continuously in large quantities. Assistance was given to them by several of the largest iron works in Sweden, and their experimentation is an interesting example of how, after several failures, a successful design was evolved which, although small modifications may be made from time to time, is now generally admitted to be one according to which all the future electric iron smelting furnaces will be built.

As many of the difficulties which had been experienced in the Canadian trials were due to the electrodes employed in the furnace, attempts were made by the Swedish engineers to design a furnace which would do away with the necessity of using carbon electrodes, and their first furnace embodied the principle of a shaft similar to that of an ordinary blast furnace, having two channels in the hearth at its base. The furnace was started as an ordinary blast furnace, arrangements being provided to introduce an air blast through twyers, and when sufficient molten iron had collected to fill the two channels, which in turn were connected to the terminals of a transformer, the current flowed between these two channels, passing through the charge, which was thereby heated sufficiently to cause fusion, and the continuous production of pig iron. The idea was that the electric heating would take the place of the heat generated by the burning of fuel in the blast furnace, and that the ore could be smelted with just sufficient fuel to reduce it to the metallic state. The lining of this first furnace was made of silica brick, and it was found that after working for short periods the heat generated on the bottom was sufficient to cause the fluxing of the brick, and after a time a short circuit occurred between the two channels.

This furnace was therefore reconstructed with a bottom of magnesite and a much more solid construction, and instead of the current being introduced through two channels parallel to one another, it was brought in at opposite sides of the furnace. The hearth lasted better than before, but the same difficulties were, in general, experienced, and it became evident that the introduction of the current through the bottom of the hearth was not likely to lead to success.

The next plan adopted was to have two electrodes placed horizontally in the shaft of the furnace, with their surfaces just flush with the interior surface of the brick work, and to have a third electrode placed in the hearth. The electrical arrangements were such that the current could be caused to flow between the two electrodes embedded in the side of the shaft, or between these two electrodes and the electrode embedded in the bottom. Here again, although this furnace was an improvement upon either of the two types above described, yet the intense heat developed on the surface of the brick lining was such as to cause the very rapid wearing of this part, and consequently the furnace did not run very long before requiring to be relined.

It seemed, therefore, that if a successful furnace was to be designed that the electrodes should not be completely surrounded by the charge, neither should they produce their arcs close to either the lining of the furnace shaft or the bottom. A fourth furnace was constructed, therefore, a section of which is shown in Figure 1, having two parts, a shaft to contain the charge of ore and charcoal, and a melting chamber below, having an arched roof through which the electrodes projected. As in all furnaces heated by the electric arc, the point at which the heat is most intense is at the end of the electrode, but in this case this intensely heated region was kept in the centre of the smelting chamber, whilst the outside brick walls were saved most of the severe heating, which they had had to stand in the previous types of furnaces. Preliminary trials with this small furnace were successful and seemed to indicate that the correct principle had been discovered, so that, in 1908, a furnace was built upon this design improved and modified at Domnarfvet. This furnace had a shaft 20 ft. high, and was rated at 750 h.p. Three electrodes of amorphous carbon were employed to introduce three phase, low tension alternating current into the melting chamber. Further, an improvement was introduced whereby the gas produced by the reduction of the iron ore could be taken from the top of the furnace shaft, and after passing through a dust catcher, could be blown by means of a fan into the melting chamber immediately underneath the arched roof, cooling this latter, and

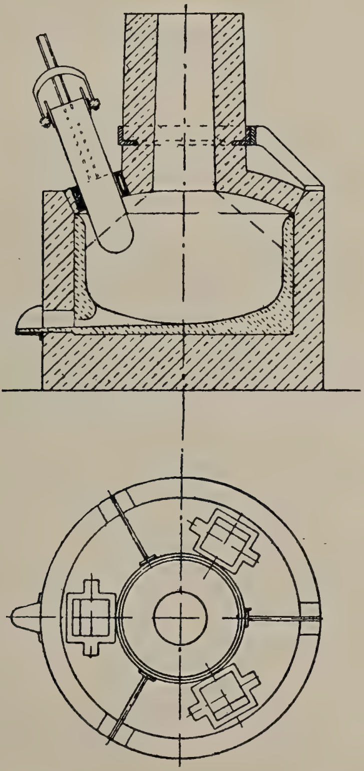


Fig. 1—Showing design followed in Domnarfvet Furnace

preserving it from being fluxed by the radiation from the intensely hot arcs. This gas, after passing underneath the roof, naturally became heated to a fairly high temperature, and as it all passed up the shaft it gave up this heat to, and assisted in the reduction of, the descending charge.

This furnace at Domnarfvet produced about 2 tons of pig iron per electrical h.p. year consumed in the furnace, and ran continuously from the beginning of May, 1909, to the 30th July, when it was closed down although in good running order, in order to make certain alterations. The consumption of electrodes was exceptionally low, considering the small size of furnace, and the fact that it was smelting iron ores, being only about 18 lbs. of electrode per ton of pig iron produced.

The results of the working of this furnace created great enthusiasm throughout the whole of Sweden, indicating as they did that some successful method of reducing the consumption of charcoal necessary to produce pig iron under the present conditions was about to be developed on a large scale. Jernkontoret, an organisation of Swedish ironmasters, founded nearly 200 years ago, which, although having accumulated large funds, had never before embarked in a commercial undertaking, determined to put up sufficient money to build a furnace similar to the one at Domnarfvet, but on a much larger scale; in fact, one comparable in every way to the Swedish charcoal blast furnace. Their intention was to smelt the various iron ores in general use in Sweden in this electric furnace, and to test the resulting electric pig iron against the Swedish charcoal blast furnace pig iron produced from the same ores, in order to determine the relative quality of pig iron produced by the two methods as well as to determine the relative costs.

The site chosen for this large furnace was at Trollhattan, where the Swedish Government has recently installed a large hydro-electric power plant, from which a supply of power could easily be obtained. The current is three phase, 25 cycles, and is generated at 10,000 volts. It was thought advisable in this particular furnace to transform the three phase current by means of two transformers, with Scott's connections, to low tension two phase current, in order to have the furnace built with four large electrodes rather than with six smaller ones, which would have been needed to use three phase secondary current. The new furnace site was supplied with railroad connections, and a large storage house for the charcoal was built to contain a six months' supply. The furnace itself is in a large brick and stone building, according to the prevailing Swedish practice. The construction of the furnace is shown in Figure 2, two separate portions are to be distinguished, namely, the shaft and the crucible or hearth. The shaft is simply a shell of steel plate lined with fire brick. At the top it is riveted to an octagonal channel iron ring, which bears on two built up beams, these being in turn supported by the walls of the building. In this manner the roof of the hearth is not called upon to support the weight of the shaft containing the charge. At the top of the shaft is a Tholander charging bell, a type of bell peculiar to Sweden, which is specially designed to deliver the ore round the sides of the shaft and the charcoal in the centre.

The crucible or hearth rests on a concrete foundation, which also has a steel shell, next to which is a lining of fire brick with an inner lining of magnesite brick, whilst the bowl-shaped bottom is formed by ramming in a mixture of magnesite and tar. The arched roof is built of fire brick and has four openings to admit the electrodes, which project through the roof at an angle of 65 deg. to the horizontal, and are surrounded at the point where they pass through the roof by a copper water jacket with asbestos packing to prevent the leakage of gas. The electrical contact pieces are wedged between the upper end of the electrode and a holder of cast steel, which is supported in a frame that can be raised or lowered between two guides, one on either side of the electrode. Figure 2 also shows the gas circulating arrangement, the function of which was described in connection with the Domnarfvet furnace. The four twyers through which the cool gas is blown are situated between the electrodes. This

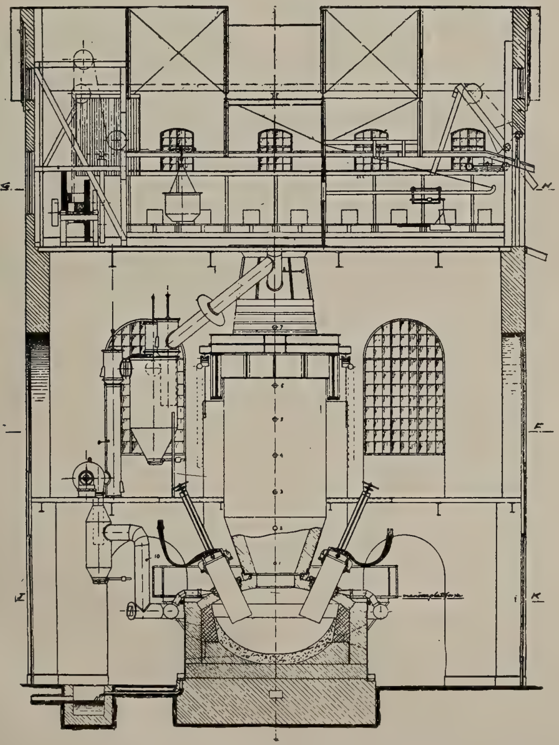


Fig. 2—Showing construction of the Trollhattan Furnace

Trollhattan furnace is rated at 2500 h.p., and current is supplied by two transformers, each of 1,100 K.V.A. capacity, oil insulated with water cooling. The tension of the two phase secondary current can, by altering the number of primary windings, be regulated in steps of 5 volts between 50 and 90 volts, and a change of tension can be made whilst the furnace is working by simply turning a hand-wheel, and arrangements are also such that the two phases can work at different tensions.

The low tension copper busbars from the transformers to the furnace are 24 in number, each 8 x 200 m.m. cross section. From these bars to the electrode holders the current is carried by flexible bare copper cables. The switchboard was fully equipped with numerous instruments in order that as much data as possible regarding the working of the furnace could be obtained. The chemical laboratory was fitted out with apparatus for the rapid analysis of the furnace gases of the various materials used and produced at the plant.

Charging was commenced, after the furnace had been thoroughly dried out, on the 15th November, 1910. In working the furnace the ore is taken from the stock pile, crushed and elevated to the furnace top, where small storage bins are provided, from which the various charges are accurately weighed out. Each charge of ore is mixed with a suitable proportion of limestone and charcoal sufficient for its reduction, and dropped into the furnace from time to time, tappings of molten iron being made about every 18 charges, corresponding to 4 tappings per 24 hours. By varying the amount of charcoal, grey or white pig iron can be produced at will, and numerous experiments were tried involving the use of different kinds of slag. This, however, was not good for the lining of the furnace hearth, and it must be admitted that it was something of an achievement for it to stand six months of such treatment without needing any serious repairs. The electrodes which were employed were built up of 4 separate pieces each 12 in. square by 6 ft. long, as at the time the installation was made carbon electrodes in one piece of the necessary dimensions could not be obtained. In order that the electrodes should not be overheated the current did not exceed 17,000 amperes, the voltage being regulated accordingly. The electrodes were only lowered into the furnace about once every two weeks in order to adjust their wear. Besides being abraided by the charge, the portion of the electrode in the free space underneath the roof of the hearth is subject to the action of the furnace gases, which contain about 20 p.c. of carbon dioxide, which unites slowly with the carbon of the electrode forming carbon monoxide gas, so that the stump ends of electrodes which have been removed from the furnace have exhibited curious shapes.

The furnace was shut down at the end of May, 1911, in order to make certain alterations suggested by the experience gained during its six months' campaign, two of these deserving mention.

1. Since the furnace was designed, the manufacture of large carbon electrodes, of high conductivity, has made great progress. It is now possible to obtain cylindrical electrodes of 600 m.m. diameter, fitted with screw joints. These have recently been installed at Trollhattan, and result in two considerable improvements, the first one being that the loss due to stump ends is done away with, as when an electrode becomes too short, a new one

can be screwed on above it. The second one is that the electrical contact can be made at the point where the electrode enters the roof, in this way saving about 40 kw., which, with the old arrangement, was lost, due to the resistance of the whole length of the electrode through which the current had to pass.

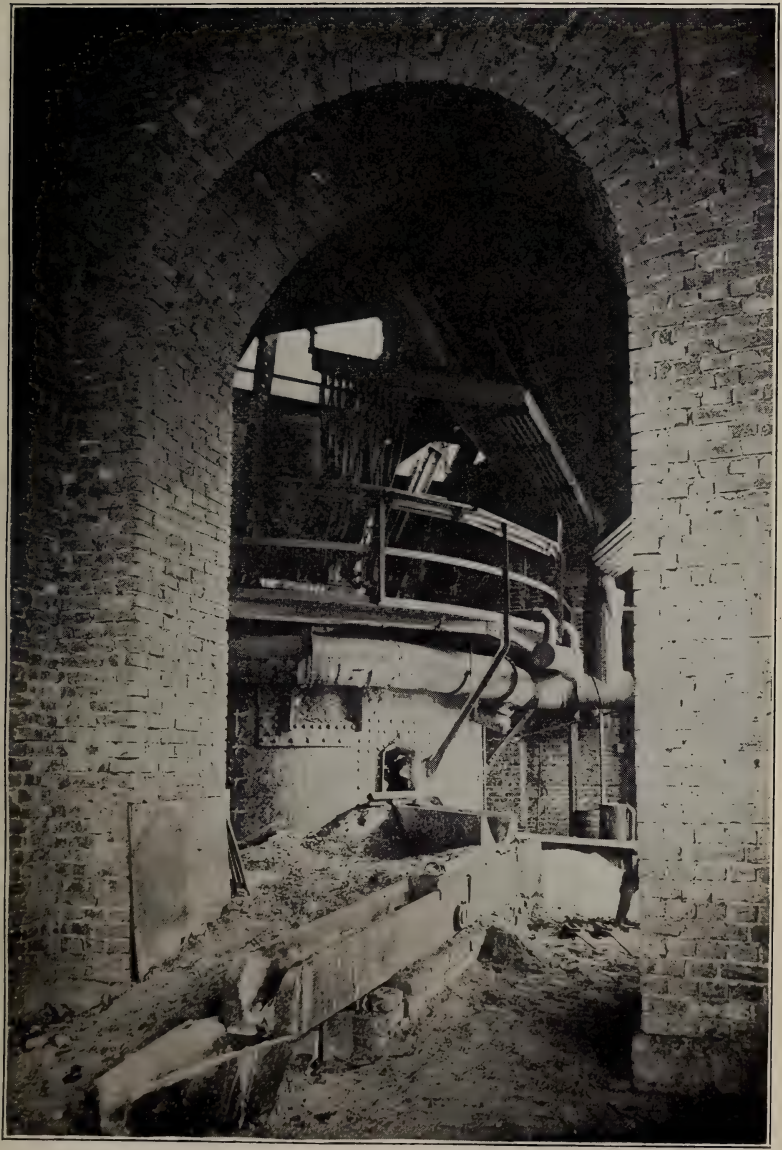


Fig. 3—General view of lower part of Trollhattan Furnace

2. The other important alteration is in the gas circulating arrangement. The old dust catcher was not very effective, as only very fine dust is expelled from the furnace. The result was that the dust collected in the centrifugal fan, and had it not been that this was kept fairly clear by a jet of water, would have choked up the blades in a few hours; as it was, the fan had to be stopped and cleaned every week. Now, a water scrubber takes the place of the dust catcher, and a fan on the ground floor blows the cleaned gas into the furnace, and the other fan shown being held in reserve.

A comparison between electric and blast furnace smelting is of interest. It has been found that rather more than 3 tons of pig iron are produced by the electric furnace for each E.H.P. year consumed, about one ton of charcoal (or coke) being necessary for the reduction of ore. To produce the same amount, namely, 3 tons of pig iron in the blast furnace, requires rather more than 3 tons of charcoal (or coke) so that the difference between the two processes, roughly speaking, consists in the substitution of one electrical h.p. year for 2 tons of charcoal (or coke). As power can be obtained in Norway and Sweden at a price per h.p. year very much less than the price of 2 tons of suitable fuel, apart from other advantages of the electrical process, a considerable saving is effected in cost. Further, by the utilization of water power in place of the burning of fuel the national resources of the countries are conserved.

The latest results obtained at Trollhattan are worthy of mention, being considerably better than those obtained at the commencement of the work. From September 3rd to September 30th, 1911, 538 metric tons of pig iron were produced, accompanied by 89 tons of slag, although the average load on the furnace was rather less than 2,000 h.p. The current used per ton of iron produced was 1,749 k.w. hours, corresponding to a production of pig iron per h.p. year of 3.68 tons, whilst the charcoal consumed was about 750 lbs. per ton of iron, and the electrode consumption was further reduced to 11 lbs. for each ton of iron produced. At the present time there are working and in course of erection in Sweden four furnaces, with a total capacity of 13,000 h.p., and in Norway four furnaces, with a capacity of 12,000 h.p., whilst in addition furnaces for about 36,000 h.p. are projected. These figures indicate that electric smelting has passed beyond the experimental stage, and in Scandinavia electric furnaces are now thoroughly established upon a commercial basis.

Some features of the possibilities of the electric furnaces are of considerable interest from a Canadian point of view. There are in Canada extensive deposits of low grade iron ores which require magnetic concentration to render them suitable for smelting. If large quantities of these concentrates are to be used in the blast furnace they require to be briquetted or nodulised, in itself an expensive process. The electric furnace at Trollhattan, although the design of shaft is not very suitable for smelting concentrates, has, during a considerable period, smelted charges consisting of over 65 p.c. of very finely divided magnetic concentrates without causing any trouble, and it is believed that by modifying the shape of the shaft, charges made up entirely of concentrates can be successfully smelted, thus saving the cost of briquetting or nodulising.

The experiments at Sault Ste. Marie, referred to above, demonstrated that it was possible in the electric furnace to produce iron with low contents of sulphur, from ores containing large amounts of that unwelcome element. Whilst this point has not been confirmed on a large scale at Trollhattan, owing to the fact that high sulphur ores are not mined in Sweden, yet there is no doubt that the electric furnace, permitting as it does the use of very high temperatures and exceedingly basic slags, is admirably suited for smelting sulphurous ores. Owing to the fact that fluid slags with high lime contents can be maintained in the electric furnace, ores containing considerable percentages of titanic oxide can be smelted without difficulty.

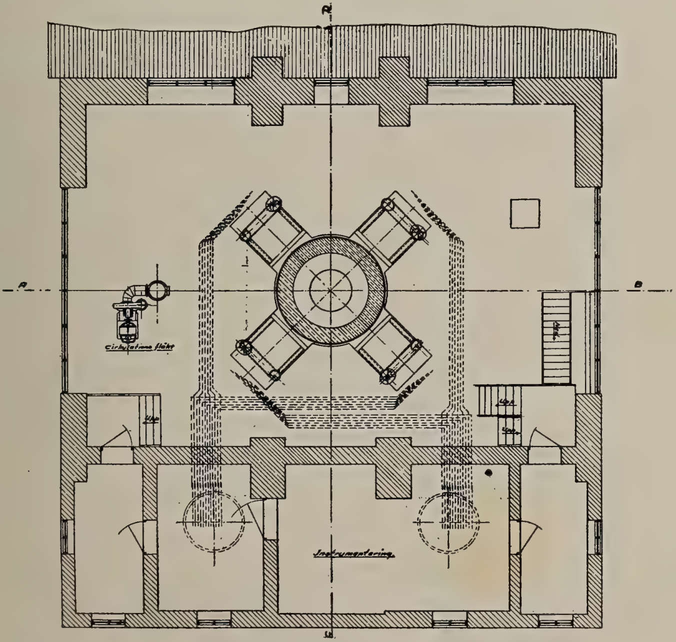


Fig. 4—General plan showing connection between Transformers and Furnace

The quality of the pig iron produced in Sweden has been subjected to severe tests, and, further, has been converted into steel in open hearth furnaces, which steel was then tested against similar steel made from charcoal blast furnace pig iron. The tests showed that the quality of the new product was in most cases equal and in some cases superior, to that produced by the older methods.

The development of the electric furnace from the early experimental stage up to the present state of efficiency has been extremely rapid, and in view of the widespread interest which its successful working has aroused, there can be little doubt that many more electric smelting furnaces will be erected during the next few years.

GRADUATES IN NEW YORK

The University of Toronto Club of New York held its tenth annual banquet on the evening of February 10th. Some seventy graduates of the University were present at the gathering. Professor Wright and Professor Alexander were in attendance as representatives of the University staff. In addition to them there were seated at the head table the presidents of the New York societies of McGill and Queen's, Alexander B. Humphrey, secretary of the American Peace and Arbitration League, and others. Among the graduates in Applied Science and Engineering who attended are noted the names of T. Kennard Thomson, Eugene W. Stern, H. F. Ballantyne, L. L. Brown, H. V. Serson, A. G. MacKay, Douglas Mackintosh, and H. P. Rust.

Mr. Walter H. Robinson, who was for many years the leader of the University of Toronto Glee Club, was present and added much to the evening's enjoyment.

The reunion was held in the banqueting hall of the Engineers' Club, on Fortieth Street.

Geo. K. Williams, '10, is in the employ of the Dominion Bridge Co., Montreal.

C. W. Connell, '11, and L. E. Jones, '11, are in the office of the City Engineer, Vancouver.

J. H. Ryckman, '06, is in the construction department of the Rock Island Railway, Chicago.

F. M. Byam, '06, formerly with Smith Kerry & Chace, in their Toronto office, has become associated with the firm of McGregor & McIntyre, Toronto.

W. G. Turnbull, '09, is the chief engineer of the Turnbull Elevator Company, whose headquarters are in this city.

L. C. Mitchell, '11, is employed in the chemical laboratories of the Guantanamo Sugar Company, Cuba.

C. A. O'Gorman is on construction work for the Canadian Northern Railway at Carillion, Quebec.

THE ANNUAL DINNER

As a medium of controversy and communication between the University and the industrial forces outside, this twenty-third annual reunion of the graduate and student members of the Engineering Society accomplished its object in the usual successful manner. For their splendid management and enthusiasm, to the members of the executive is due a good measure of thanks, and as an event to reflect upon, they should feel justly proud. For a number of years the dinners have been the means of increasing intercourse between this institution and Canadian commercial corporations. To recapitulate, last year the guest list included a hundred or more members of boards of trade throughout the province. The representation was admirable and the widespread interest outgrowing from the event could not have been otherwise than beneficial. In 1910 the Canadian Manufacturers' Association were invited and were present in large numbers. Dr. J. A. MacDonald, Mr. P. W. Ellis, and Mr. J. P. Murray were among those who added fuel to the awakening interest in Canada's industrial education problem. Three years ago the Canadian Society of Civil Engineers, about two hundred strong, were guests of the Engineering Society. This brilliant occasion, which was the largest dinner in the history of the institution, is very fresh in the memory of all who were present. And so on. The first annual dinner, on January 31st, 1890, with its total of fifty-four, has had its repetitions yearly, each evidencing the deeply-rooted loyalty of every School man to his Alma Mater, his interest also in the outer world, and its interest in him. As the anniversaries accumulate in the annals of the School, the term "outside" on the one hand, and on the other the term, "highbrows on College Street" are each llosing all sense of significance, and a bond of union is steadily assuming the place. The relation is still exceedingly small in comparison with what it will be when it is more universally realized that the University aids industrial and commercial progress in a manner no other influence can. The strides are ever in the right direction, and the product of academic training is the force that is foremost in completing the span. The dinners of the Engineering Society have thus an assigned function, and the problem that yearly taxes the ingenuity of its executive officers is the utilizing of the opportunity to the very best advantage.

This year Mr. McPherson and his men displayed excellent judgment in inviting to their dinner the Commission of Conservation. At no time other than the present has there been the universal interest attending the conservation of Canadian resources. Too many tales are truthfully told of the economic waste in other countries. Neglectfulness and lack of national foresight has cost many their best assets to strength and prominence among the nations of fifty years hence, and the results were grim in outlook when conservation measures were first enforced in some lands. Canada's Commission of Conservation, in its three years of active service, and in its service to come, are storing up volumes of prevention against such conditions here. Their work merits the praise and approval of every domain, and all domains deign to keep an admiring eye upon the transitions of this young country. The Commission is merely an advisory board, depending upon the co-operation and support given it by public opinion, and by the adoption of its recommendations, yet the work of the Commission thus far has been effective to an exceedingly satisfactory degree. The investigations in forest preservation, lands, mineral resources, fisheries, town-planning and housing, water and water powers, are among those which already show remarkable results in the comparatively short duration of time in which the committees have been in operation.

Not all the members were able to be present. The Commission opened its third annual session in Ottawa just several days previous and a number were detained. From those who were with us, however, a valuable summary of the aims and accomplishments was obtained, the work already done, that to do, and the parts requiring the skill of the engineer. Upon them was impressed, at the outset, the School man's appreciation of their endeavors, his realization of the necessity for deepest investigation, his exuberant co-operative spirit, and his aim to become a factor in the manipulation of the economic advantages of the Dominion to the best possible service.

We must not omit the fact that among our guests the most worthy of note are the graduates whose interest in society and school affairs brings them back to enjoy the evening in a manner well known to them. Approximately twenty per cent. of those present were graduates. We wish we could speak so highly of the undergraduate attendance. The men of the fourth year were the ones to take most advantage of the dinner. It appeals to them, as to the graduates, as an opportunity for associating with the stamp of men in whom it behooves them, as engineers, to be vitally interested. Some 42 per cent. of the fourth year were participants. The other years were considerably below any such percentage.

The banquet hall was beautifully and appropriately decorated for the occasion. A huge shield on the west wall standing in the centre of a general scheme of yellow, blue and white, interspersed throughout the whole surface of the wall with smaller shields and flags, bore the inscription, "The Faculty of Applied Science Welcomes the Commission of Conservation." The orchestra occupied an elevated platform on the opposite side of the hall. The orchestra is this year an innovation into the social life of the Science man, and the applause which it meritoriously received throughout the whole proceedings, indicated that there was a place for it, and that the place was being filled exceedingly well. Mr. Temple and his "Toikey-Oikestra" allowed not a dull moment to come into being, from the opening till the closing of the doors. The octette, as usual, surpassed itself in its rendering of a number of catchy selections. This year its personnel is made up of Messrs. Mickler, Chandler, Skinner, Macauley, Blackwood, McLean, Foote and Fansher. The presence of these two musical organiaztions in the school is viewed with considerable pride by old graduates, as well as the student body. That they fill a vacancy at the annual dinner was clearly in evidence.

The repast concluded, Mr. McPherson welcomed the guests in a short but extremely appropriate address. His toast to the King received the usual response of the School man. He then asked Mr. E. R. Gray to propose the toast to the Commission of Conservation of Canada, to which Mr. M. J. Patton, who attended by the special request of Hon. Clifford Sifton, he himself being regrettably prevented from being present, responded.

Mr. Patton expressed his pleasure in having the opportunity of speaking to an audience of engineers. Although this was the first time he had had the privilege of being with them he was inclined to feel quite at home because he was conscious of the fact that they were both co-workers in the same cause. The material with which both had to do was the natural resources of the country, and both were interested in seeing that the people of Canada got as much enjoyment out of the development of these resources, with the least exertion of effort, as it was possible for them to do. Conservation meant economical development, its search was for efficiency in utilization; and the whole training of the engineer made for efficiency. Any rough and ready handy-man could put together some kind of a waterwheel that would develop a small percentage of the power in a waterfall; but only a trained technical man could design a turbine that would utilize 80 per cent. of the energy from the water that tumbled over the fall. The mining engineer was likewise trying to devise methods of taking ore out of the earth with a minimum of waste, and, in similar ways, the civil, the electrical and mechanical engineer were endeavoring to get the maximum use out of the powers and stores of nature with the expenditure of the minimum effort. In their strivings for the elimination of waste and the realization of the highest efficiency in developing the natural resources of Canada, the engineer and the conservationist were as one.

Because of his efficiency in the line of his chosen work the engineer was looked up to as an authority in these things by the rest of the community. He therefore exerted an influence of no mean power upon public opinion in respect to the methods of developing natural resources; and, in exercising this influence in the proper manner, he could be of inestimable service to the work of conservation. For the conservation movement, as organized in Canada, depended entirely upon the support of public opinion for its success. The Commission of Conservation was merely an advisory body, whose efficiency depended upon the accuracy and justness of its decisions and on the thoroughness of its investigations. It was entirely non-political, and had no powers of administration whatever. Great importance was therefore attached to its ability to command public support. Its members consisted of financiers, farmers, lumbermen, engineers, educationists, in fact, prominent men drawn from all vocations, and in its ex-officio members the Dominion Government and all the Provincial Governments were represented. It was therefore in a position to promulgate its findings widely. Furthermore, it made much use of the press in spreading the propaganda of conservation, and its publications were attractively gotten up and widely distributed.

Sometimes, it might happen that the public were not far enough advanced to appreciate fully some of the policies advocated by the Commission. The task, in such a case, was to educate the people up to these projects. When a government was convinced that the people wanted a certain thing done, it never hesitated in meeting their wishes.

In the moulding of public opinion along well-defined lines of conservation, the engineers of the country, on account of their positions of authority could do much. Indeed, the Commission of Conservation had very much to thank them for already. The Canadian Society of Civil Engineers had formed a Committee on Conservation that was of very great assistance in the collection of information, and the "Water Powers of Canada," recently published by the Commission, was made possible largely through the kindness of engineers from one side of Canada to the other, in furnishing data regarding the powers of which they had knowledge.

He wished to refer to only two of the many concrete subjects concerning which public opinion needed to be definitely moulded at the present time. One of these was the utilization of peat as fuel. Up to the last year or two, no method had been found which was commercially feasible for separating the moisture from peat to such an extent as to make it useful as a fuel. Investigations had, however, been carried on by the Mines Branch of the Department of Mines, which had demonstrated beyond any reasonable doubt that peat fuel could be produced on a commercial basis to compete with coal. The fuel testing plant of the Mines Branch at Alfred had turned out 3,000 tons of peat, which had been eagerly bought by the people of Ottawa. The cost of production at the bog was $2.25 per ton, and to this was added 90c. for freight and 10c. for delivery, making a total of $3.25 per ton to the consumer. As 1.8 tons of peat were equal in fuel value to one ton of anthracite, the saving in price was evident wherever coal had to be hauled a long distance.

The demonstration of the fact that peat could be produced to compete successfully with coal was of immense importance to the provinces of Central Canada, who were dependent mainly upon the mines of Pennsylvania for their supply of fuel. There were large deposits of peat in Canada. So far as was known at present there were 37,000 square miles of peat bogs in this country, ranging in depth from 5 to 10 feet. In Ontario alone, there were 10,450 square miles, 450 of these being in settled parts. The significance of this could be appreciated when it was known that one cubic yard of bog produced about 250 lbs. of burnable peat.

There were, of course, certain interests who would not benefit in having peat seriously compete with coal as a fuel, and these, of course, were not particularly anxious to see the process of peat manufacture perfected to a higher degree than it now was. It was, therefore, incumbent upon all public spirited citizens who knew the facts to make it known that it was now possible to produce peat on a commercial basis, and it was their duty to endeavor to create a public sentiment that would favor the further perfecting of the present process of peat manufacture.

Another matter that the public should be made to realize was the enormity of our fire losses and the possibility of lessening them. Last year in Canada they amounted to twenty-one and a half million dollars, and, as a rule, averaged yearly from $2.95 to $3.00 per head of population. The average per capita loss in Germany was 49 cents; in France, 30 cents; in Austria, 29 cents, and in Italy only 12 cents. The three main causes of our large fire losses were usually given as climate, carelessness and construction. We could not make out winters warmer, but an educational campaign against carelessness could do much to lessen the number of fires due to our cold climate. In many of the states of the United States the methods of fire prevention were taught in the public schools and fire marshals were appointed to lead the fight against excessive fire losses. In a number of the states the fire marshals had justified their appointment by reducing the fire losses, and, as a natural consequence, the insurance rates. The most fruitful cause of fires, however, was the bad municipal building by-laws and their bad enforcement. In a new country it was natural that many flimsy structures would be erected, but Canada was getting old enough now to remedy this hazardous condition.

The majority of municipalities seemed quite incapable of enforcing even the kind of building by-laws they had. The last census had shown that 45 per cent. of the population of Canada was grouped in towns and cities, and, in view of the demonstrated incapacity of municipal authorities dealing with the important problems within their purview, it would be a wise thing for the Provincial Governments to consider seriously the advisability of creating Departments of Municipal Affairs to exercise a close supervision over the solution of those problems incident to the crowding together of people in centres of population.

"The success of the graduates, all over the civilized, and in the case of our faculty, the uncivilized world, is an indication of the influence of the University," said Mr. G. B. Taylor, '14, in proposing the next toast, that to the University, to which Dr. Ellis, after a perfect storm of acclaim, responded.

The doctor dwelt upon the growth of the University, under the influence of Canadian atmosphere, activities, aims and anticipations. He exemplified the influence by comparing the growth with that of the tree just east of the main building. A European maple was grafted upon a Canadian stock. Both flourished. Eventually the Canadian branches superseded in development the added branch. The difference in robust growth and strength increased, and at the present time the tree is a truly Canadian maple, the life of the European having been entirely assimilated, and the product a thorough native. Doctor Ellis' unique illlustration of the effect of surrounding forces strikingly impressed his audience, especially the younger men, many of whom had not seriously considered before the creative influence embodied in their associations with University factors in the present and future.

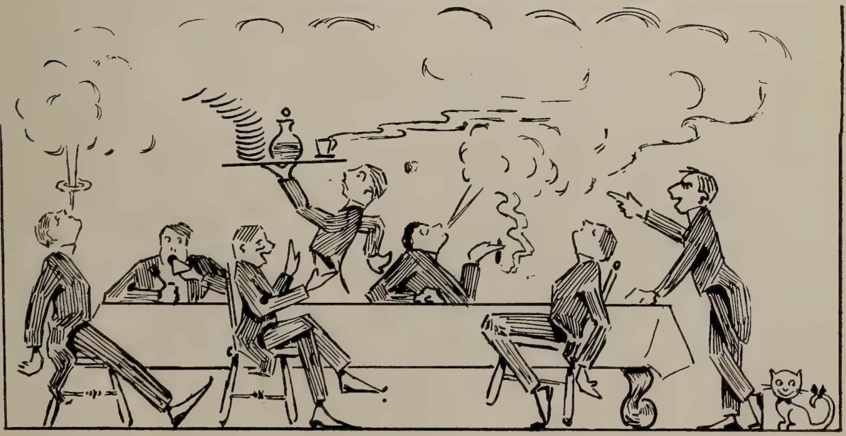
Mr. R. J. Fuller, '11, proposed an impromptu toast to the newly-appointed Professor of Metallurgy, Prof. G. A. Guess. The difficulties experienced in locating a capable head for this department, and the qualifications possessed by the man who, as a member of the staff, was in attendance for the first time at the annual dinner, were well brought out. The great welcome tendered to Professor Guess at the close of Mr. Fuller's remarks bespoke the universal appreciation of the whole assembly. In a few words of reply, the newcomer expressed with what deep feeling he accepted the welcome of the staff and students.

Mr. J. S. Galbraith, '13, proposed the toast to "The Professors." The burden of responsibilities which the young engineer was taking upon him were none too great for the men from the School to cope with. Aptly he mentioned "The School man, of course," as the engineer of to-day.

Mr. W. F. Tye, in responding, viewed with pride the engineering education obtainable in the Faculty of Applied Science. Since his student days he has kept closely in touch with University affairs. He pronounces the progress as being of the best. He dwelt reminiscently upon the joys and trials of the early days in S. P. S., and upon the influences which commence, when a man leaves college, to mould into shape the engineer-to-be. The status of the engineer to-day is vastly different from that of years ago, when a college education was deemed more of a hindrance than of a benefit when in quest of a position. Now the tables are reversed, and in this age of the engineer the technically trained man has an unsurmountable advantage over the so-called practical man. Mr. Tye gave as his best advice to the undergraduate an intimation that had been brought home to him repeatedly in this thirty years of graduate work, that of making and preserving a careful collection of cost records of all work with which one is connected. Efficiency engineering is common to all branches of the profession. It is vital in its importance, and commands the fullest consideration. No man can do better than to begin right by observing, as all may, the cost data connected with whatever work in which he may be employed.

Dean Galbraith also spoke, commenting upon the success of the event, and upon the work the Society was accomplishing. "This is one of the most successful dinners that the Society has ever held. I am in a position to know. This is the twenty-third for me."

Mr. J. B. Tyrrell, a graduate of nearly thirty years, whose professional duties has prevented him from attending many of our dinners, and whose efforts to be present were on this occasion fortuned with success, was enthusiastically welcomed, and his brief address most warmly received.



TESTS ON THE STRENGTH OF NAILED JOINTS

J. H. Thornley, B.A.,Sc., '08

In this day of steel and concrete, a discussion of anything pertaining to timber construction may seem somewhat out of place, but to the Canadian hydraulic engineer at least timber is still a building material of prime importance.

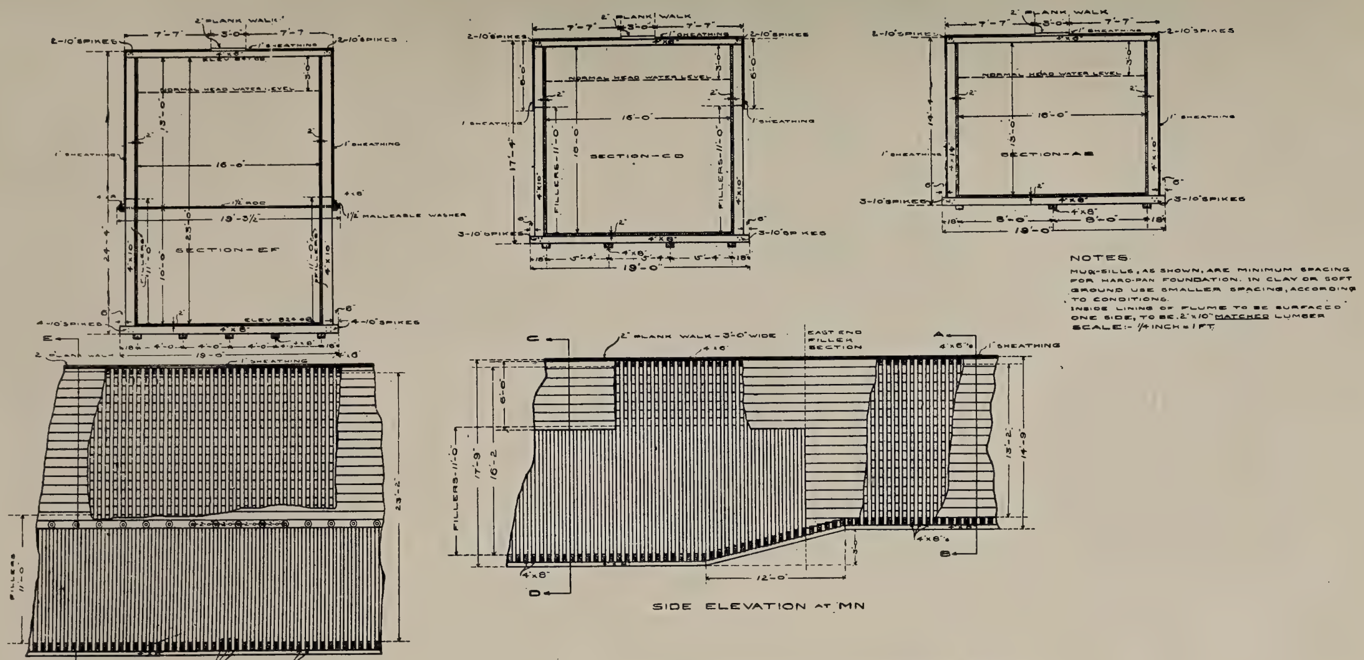
The brief nail test here reported was made in connection with the design of the Porcupine Power Company's Hydro-Electric plant at Sandy Falls on the Mettagami River, built by Mr. H. D. Symmes, of Niagara Falls, Ontario.

A word or two regarding this plant may be in place since the qualities sought in the joints tested can only be understood by a consideration of the special construction conditions.

Since the generating plant, a 4,500 h.p. hydro-electric station, was at the time of construction more than forty miles by bush road from the nearest station, and since it was essential that the plant should be constructed with the utmost speed, it was desired to cut to a minimum the use of steel, concrete or other bulky materials requiring to be brought in from the railroad. It was, moreover, desirable to use none but the simplest timber construction on account of the difficulty of turning out carefully sized lumber from a temporary sawmill, and also because it was the intention to avoid labor trouble by using lumberjacks rather than carpenters for the bulk of the work,—an obvious impossibility on work demanding careful framing.

A rock filled corn crib and stop log dam and timber power house would satisfy conditions both in the matter of construction and material, but the flume offered difficulties. The standard types demanded a great deal of steel in the form of bolts and tie rods and the use of these bolts and rods demanded a fair average degree of skill, in the gangs erecting the work. Finally, after getting out several designs, that shown in Fig. No. 2 was suggested. As will be noted, the construction consists of a corn crib, such as is used in a crib and stop log dam, only that in the case of the flume the crib is turned on its side and sheeted on the inside instead of the outside. This construction called for the use of a minimum of steel, and since practically no skill was needed beyond the ability to drive nails, the flume could be built by lumberjacks quite as well as by carpenters. The one question in doubt was that of the possibility of constructing a nailed joint sufficiently strong to withstand the hydrostatic pressure. It was to determine this point that the tests, the results of which follow, were run.

The accompanying photographs, Nos. 1 and 2, show the flume under construction. The gang shown in the first picture, all lumberjacks, erected the framework of the flume at an average rate of a little better than one hundred feet per day of twelve working hours. The flume, which has been carrying water for some time now, seems to be giving satisfaction.



NOTES.
MUD-SILLS, AS SHOWN, ARE MINIMUM SPACING FOR HARD-PAN FOUNDATION. IN CLAY OR SOFT GROUND USE SMALLER SPACING, ACCORDING TO CONDITIONS.
INSIDE LINING OF FLUME TO BE SURFACED ONE SIDE, TO BE 2"x10" MATCHED LUMBER
SCALE:- ¼ INCH = 1 FT.

SIDE ELEVATION AT PQ

NOTE: CHANGE FROM SECTION CD TO EF AT 4 TO 1 SLOPE AS SHOWN FOR AB TO CD

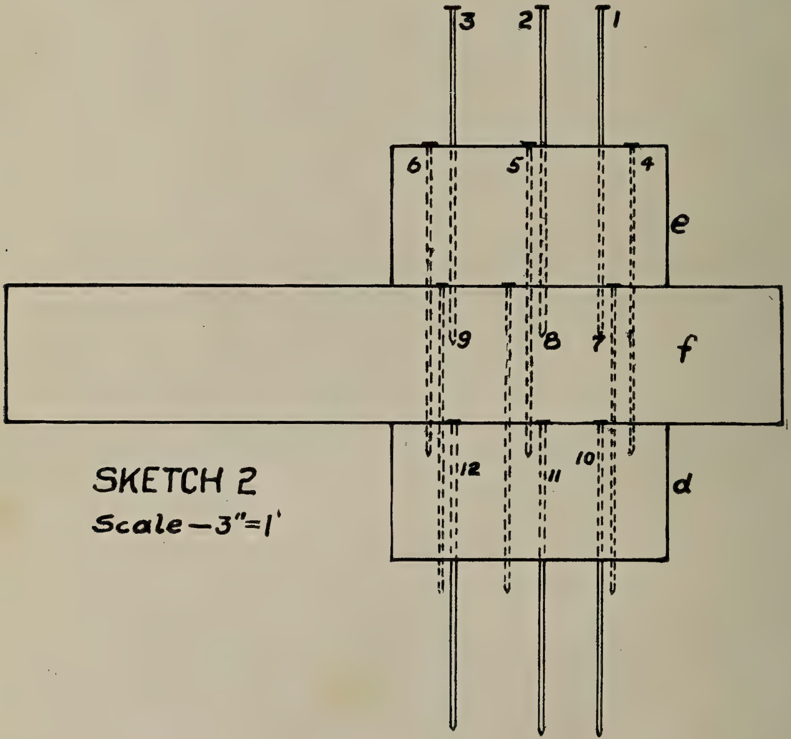
Sketch No. 1—Details of Flume

Purpose of Test

To ascertain the transverse holding power in pine lumber of nine-inch spikes (4½ to the pound), and in particular to find the permissible load on a nailed joint as used at lower corner of a corn crib flume of construction as shown in Sketch No. 1, and to find what nailing will give maximum strength for such a joint, that is, to find a nailing with which failure will be equally likely to occur by cracking of the timbers or by drawing of the nails.

Three characteristics of any timber joint of great importance are:

(1) Relation of elastic limit to ultimate load.



SKETCH 2
Scale—3″=1′

(2) Extreme permanent deflection possible without lessening of ultimate strength. This point is of prime importance since, owing to the inequalities in size of commercial lumber, more particularly in unplaned material and to unavoidable inaccuracies in work fabricated by carpenters, joints are often called upon to undergo very considerable deflections before the theoretical distribution of loads occurs.

(3) Effect of moisture and frost. The present test would have no bearing upon this point.

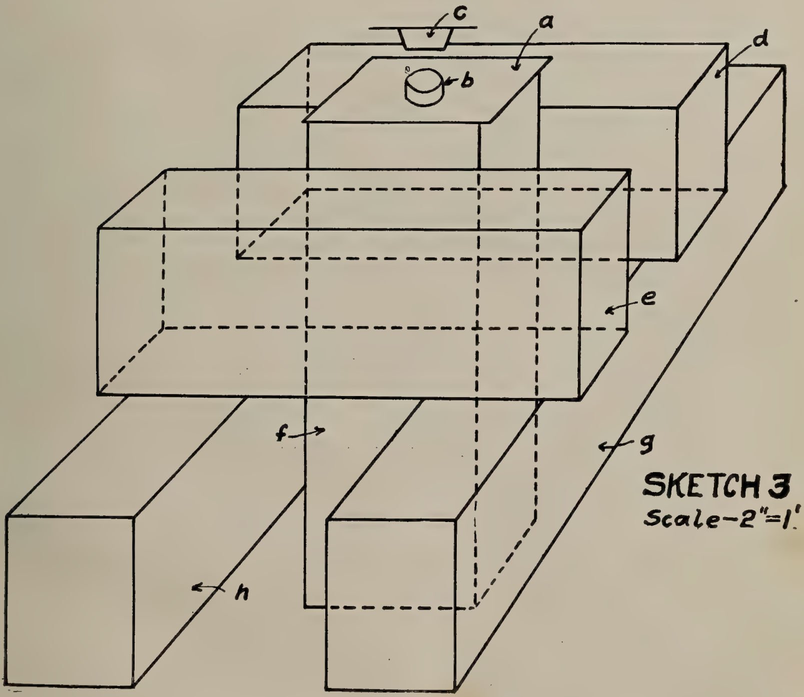
Method of Test

The specimen was made by nailing together three pieces of 4 in. x 8 in., 4 in. x 10 in., 3½ in. x 8 in., or various combinations of these sizes, as shown in sketch No. 3.

Sketch No. 2 shows the nailing used for the most of the tests.

Sketch No. 1 shows the nailed joint as used in the flume.

In Sketch No. 3—



SKETCH 3
Scale—2"=1'

"A" is a ½-in. steel plate used to distribute the load applied to the end of the 4 in. x 8 in. piece marked "F."
"B" is a universal head of the ball and socket type.
"G" and "H" are piles of blocking.
"C" is a wedge-shaped piece of steel attached to the upper or movable head of a one hundred ton testing machine.

In several of the experiments the universal head "B" was dispensed with and the load applied directly to the steel plate "A." This had no apparent effect on the results.

Analysis of Nailing in Accordance with the General Laws, as Deduced from Previous Experiments

Referring here to Sketch No. 2, which represents a joint at the lower corner of a 13 ft. x 16 ft. section of the flume, the effect of nails Nos. 1, 2, and 3 on the elastic limit load of the joint is obtained thus:

Since "grip" has no effect on elastic limit of joint, the elastic limit load of nail No. 1 should be $Cd^2 = 5500 \times (\frac{3}{8})^2 = 770$ pounds. The effect on the ultimate load of the joint will be $2Cd^2 \times \dfrac{\text{grip}}{\frac{1}{3}\text{ length of nail}}$ $= 2 \times 5500 \times \frac{9}{64} \times \frac{1}{3} = 518$ per nail if failure result from drawing of the nails.

The effect of nails Nos. 4, 5, and 6 on the elastic limit of joint must be considered for the points "A" and "B". Each nail will be effective at these points. Elastic limit load on No. 4 = $Cd^2 \times 2 = 5500 \times (\frac{3}{8})^2 \times 2 = 1540$ pounds. The ultimate load of No. 4 at "A" will be 1540 pounds and at "B" 513 pounds.

Each of Nos. 7, 8, and 9, will effect the elastic limit load to the extent of 770 pounds and the ultimate load to 1540 pounds.

Nails Nos. 10, 11 and 12 will have no effect on either the elastic limit or the ultimate load of the joint, except as they may effect a possible failure by cracking of the timbers.

Theoretical Elastic Limit Load of Joint as Shown

From No. 1, No. 2, No. 3	2310
From No. 4, No. 5, No. 6	4620
From No. 7, No. 8, No. 9	2310
From No. 10, No. 11, No. 12	0000
	9,240

Theoretical Ultimate Load of Joint as Shown

From No. 1, No. 2, No. 3	1540
From No. 4, No. 5, No. 6	6160
From No. 7, No. 8, No. 9	4620
From No. 10, No. 11, No. 12	0000
	12,320

Summary of Results of Previous Experiments Bearing on Strength of Nailed Joints

In as far as could be ascertained, no experiments have been made on the transverse strength of the nailed joints made with nails larger than 60d. (6 in.), but from experiments with 60d. and smaller sizes of nails the following general laws have been deduced:—

1. Permissible deflection of a nailed joint 1-16 in. for 60d. nails.

2. Elastic limit of joint will be one-half ultimate strength.

3. Strength of joint is directly proportional to the number of nails used and is independent of relative position of nails when failure does not occur by cracks in timber.

4. The holding power of a nail at the elastic limit is expressed by the equation Cd^2 where C is a constant dependent on the material (5500 for pine, fairly dry) and d. is the diameter of the nail in inches ($\frac{3}{8}$ in. for 9 in. spikes 4½ to the pound). This holding power is independent of the length of the grip (that is, that part of the nail between the point of application of a shearing load and the point of the nail). It will be noted that according to this equation the elastic limit is entirely dependent upon the material, under a crushing load of the timber.

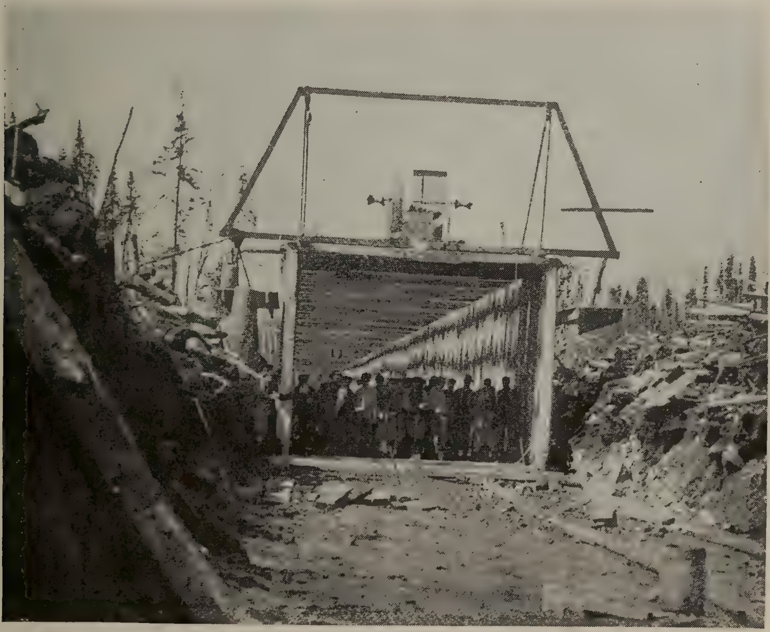


Fig. 1—Porcupine Power Co.'s Flume under Construction.

5. The holding power of a nail at ultimate load varies directly with the length of the grip up to a grip of one-third the length of the nail when it becomes practically constant and is expressed by the equation,

$$\text{Ultimate load} = \frac{2Cd^2 \times \text{grip}}{\text{1-3 length of nail}}$$

In consideration of the fact that wooden joints show a deflection of an inch or more before reaching ultimate load, a brief study of

TABULATED RESULTS

DESCRIPTION OF SPECIMEN.							
Number.	CONSTRUCTION. NOTE: See Sketch No. 3.	METHOD OF NAILING NOTE: See Sketch No. 2	REMARKS ON LUMBER USED	Load in pounds at which first signs of failure were noted.	Load in pounds at ultimate failure.	Number of 100% effective nails equivalent to nailing as used. Equation—$\text{Ult. L} = \frac{\text{grip}}{\text{1-3 length}}$	Number of 100% effective nails equivalent to nailing as used. Equation $\text{Ult. L} = \frac{\text{grip}}{\text{1-3 length}}$ constant.
1.—	D. & E: 4 in. x 10 in. F: 4 in x 8 in.	8 NAILS 2 to each piece of specimen	Pine rough. Fairly dry. Material fair	8200	9500	5 1-3	6
2.—	D & E: 4 in. x 10 in. F: 4 in. x 8 in.	12 NAILS 3 to each piece of specimen, driven as indicated in Sketch No. 2	Pine rough Fairly dry Good condition	14000	15960	8	10
3.—	D & E: 4 in. x 10 in. F: 4 in. x 8 in.	16 NAILS 4 to each piece of specimen, driven as indicated in Sketch No. 2	Pine rough Fairly dry Good condition	19000	21000	10 2-3	13 1-3
4.—	D, E & F: 3½ in. x 8 in.	12 NAILS 3 to each piece of specimen, driven as indicated in Sketch No. 2	Pine planed Fairly dry Fair condition	12000	16070	10	12 2-3
5.—	D, E & F: 3½ in. x 8 in.	8 NAILS 2 to each piece of specimen	Pine planed Fairly dry Weather cracked	9840	11550	6 2-3	8
6.—	D, E & F: 4 in. x 8 in.	12 NAILS 3 to each piece of specimen, driven as indicated in Sketch No. 2	Pine rough Fairly dry Fair condition	14400	16350	8	10
7.—	D, E & F: 4 in. x 8 in.	12 NAILS 3 to each piece of specimen as in Sketch No. 2	Pine rough Fairly dry Fair condition		16000	8	10
8.—	D, E & F: 4 in. x 8 in.	9 NAILS 3 Nails with 1 in. hold omitted	Pine rough Fairly dry Extra Good material	13000	16500	7	8

NOTE:—Observations of Elastic Limit Load were entirely unsatisfactory since the specimens showed large permanent deflections under the first 25% or less of the load but even when the specimen had been stressed almost to the point of failure with corresponding deflections of an inch or more the load could be released and again brought about above the previous high point without causing any material increase in deflection beyond that which had resulted from the first loading.

OF EXPERIMENT

Observed average ultimate load in pounds per 9 in. spike 100% effective. Equation: $L = \frac{\text{grip}}{\text{1-3 length}}$	Observed average ultimate load in pounds per 9 in. spike 100% effective Equation: Ult. $L = \frac{\text{grip}}{\text{1-3 length}}$ constant	Calculated ultimate load per 9 in. spike 100% effective. Equation: Ult. $L = 2\ Cd^2$	Calculated load elastic limit in pounds. Equation: El. $L = Cd^2 \times$ No. nails. No consideration taken length grip.	Observed load in pounds at elastic limit of joint.	REMARKS
1770	1580	1540	6160	See Foot Note	The values of the joint are the values as governed by the nails
1990	1590	1540	9240	" "	The values obtained are the values of the joint as governed by the nails for in this case failure resulted from the drawing and bending of the nails.
1950	1570	1540	12320	" "	The values observed are the values of the joint as governed by the nails for in this case failure took place by the drawing and bending of the nails.
1600	1320	1540	9240	" "	The values obtained are the values of the joint as governed by the wood for in this case failure resulted from the cracking of the nails of the piece lettered "E" in Sketch No. 3.
1750	1440	1540	6160	" "	Failure as in No. 4.
2040	1630	1540	9240	" "	The values obtained are the values of the joint as governed by the wood for in this case failure resulted from the cracking of the nails of the piece lettered "E" in Sketch No. 3.
2000	1600	1540	9240	" "	The values of the joint are the values as governed by the nails since in this case failure resulted from the drawing of the nails, therefore 1600 represents the holding power of the nail.
2360	2060	1540	6930	" "	The results from this specimen, as will be noted, show very poor agreement with the other theoretical values or with the observed values of the other seven specimens. This is probably, in part at least, a result of the extra good lumber used. It is included as showing a probable limiting maximum value for the nails.

Sketch No. 2 would suggest that the ultimate load on the joint shown must be taken up by the nails in two ways.

(a) By a resistance to withdrawal from the wood.

(b) By a bending of the nail resulting from the shearing force and the resistance to crushing of the wood. Since nails with a grip of an inch or better are bent into very similar curves, this second element does not vary with the grip but is constant. A more reasonable equation for ultimate load for a nail as governed by grip would appear to be

$$\frac{(2\ Cd^2 \times \text{length grip plus } X \text{ times } Cd^2).}{\text{1-3 length nail}}$$

The value of X as assumed in these experiments was two-thirds. It will be noted that the value of this expression is dependent upon the modulus of elasticity of the timber and the steel in the nails.

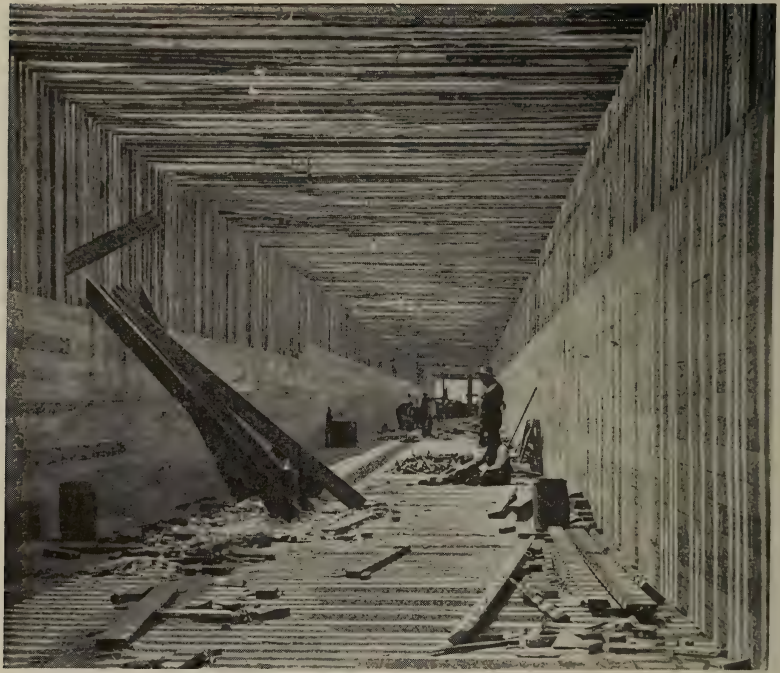


Fig. 2—Showing Flume Nearing Completion.

Notes on Results of Experiment

To design a well proportioned joint it was necessary first to ascertain the laws governing the holding power of a 9 inch spike in cases where the failure took place by drawing of the spikes, that is, to find the value of one spike, and second to find the limiting number of spikes which would develop their full load value (that is, would not cause failure by splitting) in a joint made up of 4 in. x 8 in. pieces. The 8 in. dimension was fixed by the load on the side of the flume under consideration.

Specimens Nos. 1, 2, and 3 were made with 4 in. x 10 in. used as cross pieces (failure by cracking would occur in the cross pieces if at all) and with two, three and four nails per piece respectively. In every case the failure of the joint took place in the nails, and since the results were quite uniform (1580, 1590, 1570 average per nail respectively) it may reasonably be concluded that these values would hold for 9 in. spikes in pine regardless of the dimensions of the timbers.

Fig. 3—Interior of Porcupine Power Co.'s Generation Station, Showing Units No. 1 and No. 2

In experiments Nos. 4 and 5 the number of nails was as before, but the timbers were reduced from 4 in. x 10 in. to 3½ in. x 8 in. Failure occurred at a much lower value per nail than with the 4 in. x 10 in., which would suggest a failure of the timbers, this was in agreement with the observations.

In experiments Nos. 6 and 7 the nailing was as before, but the timbers were of an intermediate size 4 in. x 8 in. Failure occurred at about the same average load per nail as in experiments Nos. 1, 2 and 3, but while in No. 6 failure occurred by breaking of the timbers, in No. 7 the failure was due to bending and drawing of the nails. The proportioning of nails to timber was, therefore, about correct.

Omitting experiment No. 8 and averaging the values of a 9 in. spike as found in the remaining four experiments where failure took place by drawing of the spikes and using number of nails as found by equation, $\frac{\text{grip in inches}}{\text{1-3 total length}} - \text{const.}$, we get 1570 as ultimate load value in shear of 9 in. spike in pine, as against a theoretical value of 1540 pounds. The greatest divergence of a single experiment from the average was 60 pounds.

Supposing the effect of the relation of grip to total length to be as suggested by Merriman, that is, the efficiency of the nail varies as $\frac{\text{grip in inches}}{\text{1-3 total length}}$ up to a grip equal to 1-3 of the length, the average value of a nail as found by the experiments would be 1920 pounds, and the greatest variation from this shown by any experiment would be one hundred and fifty pounds.

Therefore the equation introducing a constant for the effect of the bending of the nails seems, both from the standpoint of theory and observation, to be somewhat the nearer to the truth, though the experiments were far too few in number to in any sense settle this point. The constant assumed, 2-3 Cd^2 where C for the lumber used $= 5500$, and $d =$ diameter of nail in inches, was in all probability somewhat excessive.

In the light of subsequent experience in actual field construction, the writer would judge that the value of C should be, for commercial grades of pine, somewhat higher than 5500, while the fraction two-thirds might with advantage be reduced to one-third or less.

Adverting to the summary of the results of previous experiments:

(1) The permissible deflection value of 1-16 inch, that is, deflection which can be caused without weakening the joint, is altogether too small. Joints tested to deflections of an inch and more seemed to be in no way weakened. This is a very strong point in favor of the nailed timber joint.

(2) As has been pointed out, no satisfactory results were obtained regarding the relation of elastic limit to ultimate load. The percentage relation of elastic limit to ultimate load would depend on the definition assumed of elastic limit, but for practical purposes there can be no doubt that it is at least fifty per cent.

(3) The relation stated between the strength of a joint and the number of nails used, that is, that strength of joint is proportional to number of nails and entirely independent of arrangement of nails where failure does not occur by cracking of the timbers, was entirely borne out by the experimental results. Various arrangements of the nails were tried, the nails of almost every specimen being differently spaced, but as will be noted, no material difference in holding power resulted.

INSTRUMENT TRANSFORMERS AND THEIR COMPENSATION.

By Harold A. Cooch, B.A. Sc.

Voltage Transformers.

The measurement of high voltage is a problem which is taken care of usually by two or perhaps three methods—

(*a*) Spark gap method.

(*b*) Electrostatic voltmeter.

(*c*) The use of a small transformer to step down the voltage to a standard which is usually about 100 volts.

The object of this paper is to exemplify a few important facts concerning transformers for meter service.

Voltage transformers are subject to the effects of regulation similar to any other transformer, although, generally speaking, the effect is not so noticeable, due to the fact that their load is small in comparison to their total capacity.

Since the accuracy of the ratio depends on the regulation it is therefore apparent that where accuracy is essential, especially in determining voltages as sent out from a power plant, it is necessary to design a voltage transformer with a comparatively small drop in voltage for ordinary loads. For this reason it is customary to work the copper at a very low value, which ranges usually between 1.5 to 2 watts per lb. Distributing transformers are usually worked at about 4 watts per lb., while large water-cooled transformers have copper losses of about 10 watts. per lb.

On the operation of wattmeters from commercial sources a slight difference of phase between primary and secondary voltages and currents will render quite a change in the wattmeter readings, and is also therefore an important item in the design. This phase displacement between primary and secondary is due to the exciting current, and in order to minimize this error we must have our exciting current as low as possible.

Since the exciting current is the resultant of the magnetizing and core loss currents, it is obvious that we must work our iron at a very low flux density, and also design our magnetic circuit with as low a reluctance as possible.

The flux density usually considered in the design is 7,500-8,000 lines per square centimetre, as compared with 10,000-11,000 lines per sq. cm. used in the case of lighting transformers.

The limitation of the reluctance in the magnetic circuit is taken care of by enlarging the section of iron where joints are necessary, and consequently lowering the flux density at these points. The phase displacement in the voltage transformer is then quite small, so that except in special cases it is absolutely neglected.

The object of compensation then in voltage transformers is an annulment of the effect of regulation, i.e., to raise the secondary voltage to such an open circuit value that when load is applied the voltage will fall to the 100% value desired, and is accomplished in either of two ways, or both—

(*a*) Dropping a few turns from H.T.

(*b*) Adding a few turns on the L.T.

The adjustment is preferably made on the high tension winding, be it primary or secondary, due to the smaller effect of each turn.

For successful compensation the voltage, frequency and load on which the transformer is to be used must be known and a transformer compensated for a given set of conditions should not have any of these conditions vary more than 5% either way. Consider now the calculation of this compensation:

(1) Consider the cause of *IR* drops in the primary winding, *P* Fig. 1.

I_p, due to the load, is in phase with E_p for a power factor of 100%

I_c, the current necessary to supply the iron losses is in phase with E_p.

I_m, the magnetizing current necessary to magnetize the core to the given flux density is in quadrature I_{ex} is the exciting current required in the primary and is the resultant of I_c and I_m see Fig. 3.

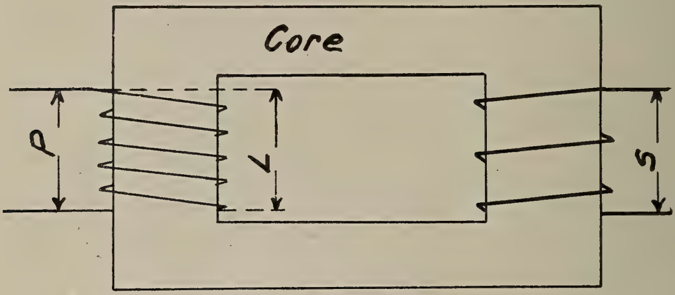


Fig. 1

(2) The load current I_s is the only cause of *IR* drop in the secondary.

Consider in Figure 3 primary conditions for a load of say 50% *PF*.

To find the drops in voltage in the primary from the above figure:—

We have the following drops in phase with the primary voltage where R_p = Primary Resistance.

1. Drop due to component of load current in phase with the voltage $= I_{p_l} \cos \theta \, R_p$

$$= I_{p_e} R_p$$

where I_{p_e} = the energy component of current.

2. Drop due to the current supplying the core losses $= I_c R_p$

3. Leakage reactance due to I_m, the drop due to this will be in phase with E_p since is it 90° out of phase with I_m and this I_m is already in quadrature with E_p.

To calculate the reactive drop $I_m X$ due to leakage we use the following formula, assuming a core type transformer as in Fig. 1 although the same formula can be supplied to shell type transformers with concentric coils.

$$\text{Reactive Drop} = \frac{210 \times I_m \times T^2 \times f \times r\,(X + Y + 3G)}{10^9 L}$$

Where T = Primary turns
r = mean radius of air gap i. e. between primary and secondary

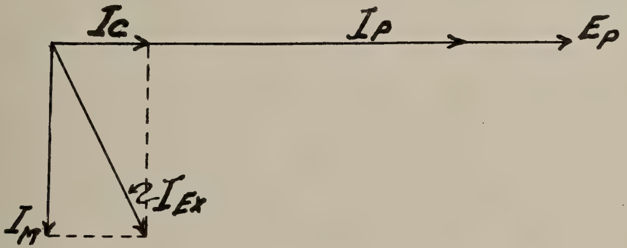


Fig. 2.

f = frequency in cycles per sec.
X = Radial thickness of primary ($H.T.$)
Y = Radial thickness of secondary ($L.T.$)
G = Radial thickness of air gap.
L = Length of coil axially as shown in Fig. 1. (This quantity in the case of coils on two legs must be doubled).

4. The wattless component $I_{p_w} W$ of the load current I_{p_l} produces a reactive drop in phase with E_p and must therefore be considered. For a load of 100% $P.F.$, however, such a drop is not present.

The value of this drop is calculated from the above formula substituting I_{p_w} for I_m and = say $I_{p_w} X$

The drops in quadrature can easily be seen to be:—

1. Reactive drop due to I_{p_e}
2. Reactive drop due to I_c.
3. Magnetizing IR drop $= I_m R_p$
4. Wattless component of load current IR drop $= I_{p_w} R_p$

To be absolutely correct the resultant of the quadrature and in phase drops should be found and the per cent. calculated, but for all practical purposes (with the exception of very low power factors) only the in phase drops with E_p are considered.

Total in phase drop in primary.

$$= I_{p_l} \cos\theta \, R_p + I_c R_p + I_m X + I_{p_w} X$$

and % drop in primary.

$$= \frac{I_{p_t} \cos\theta \, R_p + I_c R_p + I_m X + I_{p_w} X}{E_p} \times 100$$

The only drop in the secondary winding is that due to the load current.

Let I_s = Secondary current
R_s = Secondary resistance
E_s = Secondary terminal voltage.

$$\therefore \% \text{ secondary drop} = \frac{I_s R_s}{E_s} \times 100$$

Having found the total *percentage* drop in the transformer, this simply has to be expressed in secondary volts to get the desired secondary voltage under required conditions of load.

A concrete example of compensation might be cited as follows:—

A certain power company required a special portable transformer with a H.T. voltage of 2200/1100 for operating relays and recording wattmeters which apparently required exactly 110 volts supplied to them.

Each transformer was to be designed for 100 watts and compensated for 15 watts at 20% Power Factor.

According to calculations the number of *L.T.* turns was 125. Consequently the number of *H.T.* turns before compensation will be 2500.

On account of the very low power factor (20%) and on account of the accuracy required, the primary quadrature drops had to be considered.

It was not necessary in the *L.T.* on account of the fact that the inductance is low because of the low number of turns.

The following % drops were found:

%drop in *H.T.* in phase with E_p = .18%
% drop in *H.T.* in quadrature with E_p = .218%
Resultant drop in H.T. = .28%
% drop in *L.T.* = .19 at 100% *P.F.*
= .0375 at 20% *P.F.*

∴ Total drop—.317%.

∴ The number of secondary open circuited volts required $= 110 + \dfrac{.317}{100} \times 110 = 110.35$ volts.

Consequently the number of volts per turn in the primary must be increased in the proportion of 110.35 to 110 and ∴ the number of primary turns must be decreased in the inverse ratio of 110.35 to 110.

$$\text{Or number of primary turns} = \frac{110 \times 2500}{110.35} = 2492.$$

So that we must wind the *H.T.* with 8 turns less. This will change the reactance slightly and a second calculation would give us a closer value. However this step is hardly necessary.

The transformer considered above when tested was found to give the required voltage under the stated conditions exactly.

Current Transformers.

In the case of very high currents it is customary to use what is known as a current or series transformer. This is sometimes used to insulate the line voltage from the meter service. This transformer consists of a few or perhaps one primary turn with a secondary winding of a number of turns depending on the ratio of transformation required.

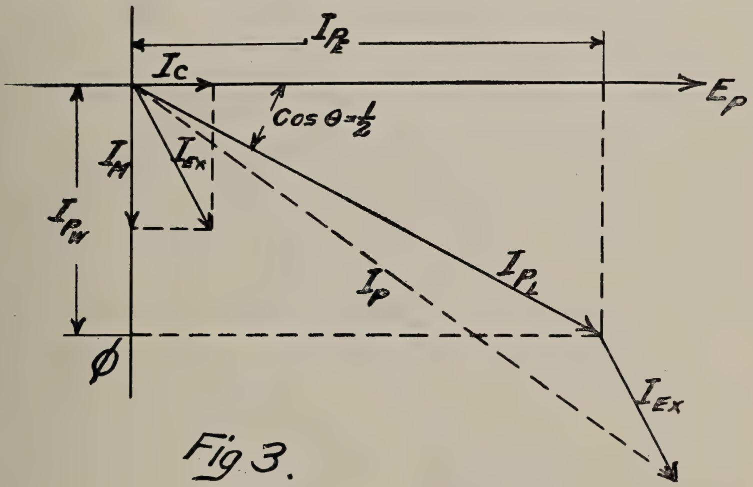


Fig 3.

In the ideal transformer the ampere turns primary are equal to the ampere turns secondary, but in the actual transformer this is not strictly true due to the core loss and magnetizing current.

It can be easily seen, since some of the current in the line, i.e. the primary current, is required for magentization and core losses that the actual volts per turn will be less than would be the case if the whole primary current were effective in producting induction. For this reason the number of turns in the secondary should be correspondingly decreased as follows:—

Let T_p, T_s, I_p, I_s be the primary and secondary turns and amperes respectively.

Then $T_pI_p = T_sI_s$ (For the ideal transformer).

Suppose I_m = magnetizing current.
I_c = Current supplying the core loss.

The actual current in the primary which induces a voltage in the secondary is then the vector difference between I_p, I_m and I_c $= I_r$.

The value of I_r can be found from vectors as shown in Fig. 4.

The construction involves a 100% *P.F.* but will apply for any power factor.

Insert then this value in the equation for the ideal transformer. expressed vectorially.

$$I_r = I_p - I_c - jI_m$$

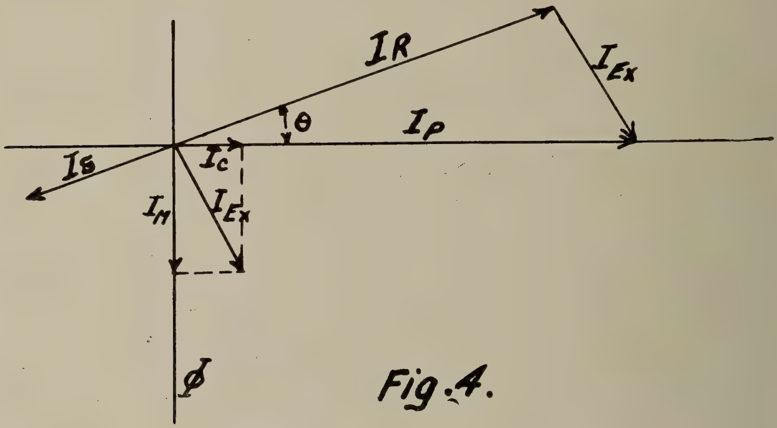


Fig. 4.

jI_m indicating a vector of value I_m in quadrature with I_p or I_c.
Formula for transformer now becomes:

$$T_pI_r = T_sI_s.$$

$$\therefore T_s = \frac{T_p}{I_s}(I_p - I_c - jI_m)$$

If $T_p = 1$, as in the case of a great many current transformers,

$$\text{Then } T_s = \frac{I_p - I_c - jI_m}{I_s}$$

I_c is determined from the design knowing the dimensions of the iron circuit, voltage which transformer is required to generate as a choke coil and data on iron used.

I_m is found from data on iron and iron circuit. Since the compensation in the case of a current transformer is expressed in ampere turns, then the formula becomes

$$T_sI_s = T_p (I_p - I_c - jI_m)$$

For ordinary commercial transformers this value of ampere turns compensation is 20 where the transformer is designed for 800 ampere turns.

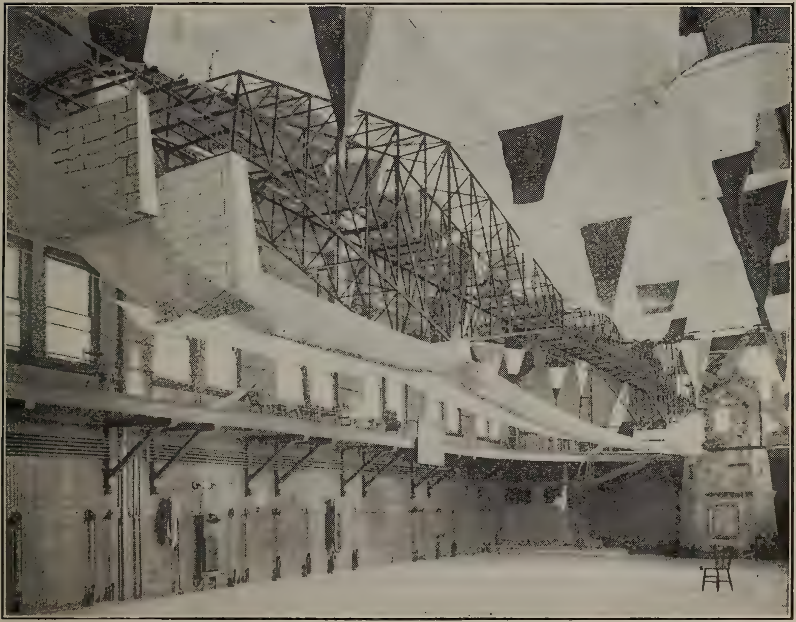
By a glance at Fig. 4 it can be seen that θ is approximately the phase displacement of the current transformer. On light load operation, say 15%, this phase displacement might run as high as

10°, which in the operation of a wattmeter might cause a considerable error. Under full load conditions the same transformer had about 3° displacement.

It is, therefore, apparent for accurate meter readings, when use is made of instrument transformers, that proper compensation is absolutely essential.

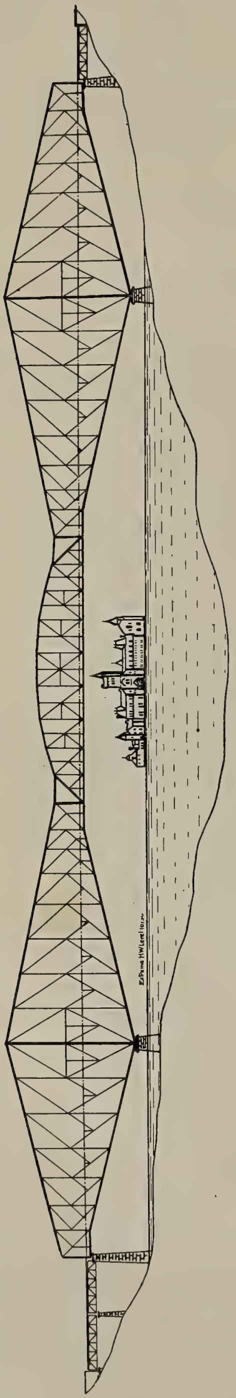
THE SCIENCE DANCE AND ITS ENGINEERING FEATURES

On Friday evening, Feb. 9th, the coldest night in seventeen years, the Engineering Society held its second annual At-Home, in the University Gymnasium, and, for several reasons, it is one that will be remembered.

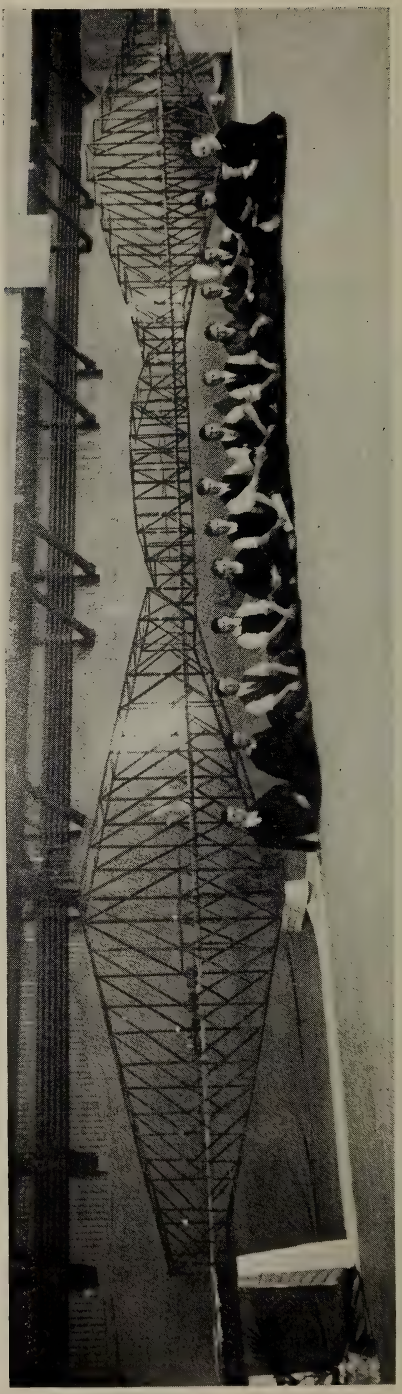


The Science Dance—View of the " Bridge " after the Removal of Wall Decorations

Historically, it is the last of all the brilliant social functions to be held in the old gymnasium, and in brilliancy it outshone all its predecessors. The floor was good, the music excellent, and the decorations all that could be desired. The walls and ceilings were completely covered with yellow, blue and white bunting, and a very successful system of indirect lighting installed, the light being furnished by forty 100 watt Tungsten lamps, which were concealed in ten inverted domes hanging from the ceiling. The light was thrown upwards against circular reflec-



Relative Sizes of the Quebec Bridge and Main Building, Universily of Toronto.



The Bridge Reproduction, and the Staff of Engineers who are Responsible for the Work.

tors six feet in diameter, which in turn reflected and diffused the light in such a manner as to give a most pleasing effect.

An attractive feature at the east end of the gymnasium was a model of a Dutch windmill. The credit for its striking appearance is due to the artistic taste of the fourth year students in architecture, and for its mechanical perfection to the untiring efforts of their colleagues in the mechanical and electrical departments. The tower of the windmill was about twenty feet in height, and the sails in proportion. The motive power was furnished by a one-eighth horse-power electric motor from the electrical laboratory. The feat of reducing the speed from that of the motor to that of the sails was accomplished by the use of a carriage wheel as a belt pulley. The only thing lacking in the installation was grease, the mixture of soap and oil used for lubricating purposes proving unequal to the occasion, resulting in the realistic squeak. At one time the creaking of the wooden shaft so rivalled the orchestra in the volume of sound produced that the musicians threatened to suspend operations if the mill did not cease its competition.

The most novel and striking feature of the decorations was a model, one-fiftieth size, of the new Quebec Bridge, which is being built by the St. Lawrence Bridge Co. The model measured over all about sixty-five feet in length, six feet in height, and two feet in width. It was suspended from the ceiling by sixteen wires one-sixteenth of an inch in diameter. On the floor of the bridge a double track railroad was laid, on which a miniature train was operated by means of electricity, the controlling switches being placed in the gallery. As the rails were not securely fastened to the ties the train service was brought to an untimely end by the locomotive eventually trying to crawl down between the rails to enjoy the revelry on the floor below. Rows of six candle power electric lights were placed along each truss, and bunting was draped about the bridge and piers to represent the water and banks of the river.

The structural parts of the model were designed and constructed by the fourth year students in Civil Engineering, with some assistance from students of the other years. The railroad and lights were installed by the mechanical and electrical students. In the structure were used about seven hundred feet run of clear pine one-half inch square, about the same amount three-quarters of an inch square, and about one hundred and fifty feet one inch square, with annealed iron wire, nails, tacks, and black tape, ad infinitum, not to mention the paper and cardboard in the piers. The bridge received one coat of black paint consisting of lamp black mixed with water and a small quantity of glue.

The work of construction consumed all the students' spare time for about two weeks, and probably some time that was not spare.

A description of the dance would not be complete without mention of the supper, which was served in quite an unusual manner. After the ninth dance, a sufficient number of tables were run in upon the floor of the gymnasium to accommodate all the guests, who sat down in quartettes to a very substantial repast.

The following patronesses were present and received the guests: Mrs. Falconer, Mrs. Galbraith, Mrs. C. H. C. Wright, Mrs. Haultain, and Mrs. A. T. Laing.

The accompanying sketch is shown in order to give a comparison of the size of the Quebec Bridge, when finished, with that of the main building of the University, both being reproduced to the same scale. The other photos give an idea of the appearance of the structure as reproduced by the Science men.

A. C. Spencer, B.A.Sc., '07, for two years with the McClary Company, London, has associated with the Hamilton Stove and Heater Co., as their mechanical engineer.

The following are among the graduates in electrical and mechanical engineering employed by the Canadian General Electric Company, at the Peterborough shops: W. H. Philip, '09; J. J. O'Hearn, '09; T. E. Freeman, '09; H. J. McTavish, '10; A. L. Sutherland, '10; H. K. Wyman, '11; T. J. Farrelly, '10.

Professor L. B. Stewart was elected president of the Royal Astronomical Society of Canada at the recent annual meeting of the society.

Mr. E. L. Cousins, B.A.Sc., '06, has been appointed to the position of engineer to the Harbor Commission of Toronto. Mr. Cousins has recently been assistant engineer, having had charge of the railway department and of bridges and docks.

We regret to announce the death at his home in Nortonville, Ont., of W. T. S. Ruston, who succumbed to pneumonia on January 17th. He was a member of the second year.

The Canadian Forestry Association met in Ottawa on Feb. 7th and 8th. Forest conservation was a problem receiving a great deal of consideration and discussion. The evening session of the first day was in the form of a banquet, in which the Canadian Lumbermen's Association joined, this body having held their annual convention on the 6th inst.

Mr. A. J. Latornell, '03, city engineer for Edmonton, has resigned to accept a similar position elsewhere.

Professor Angus gave an illustrated lecture to the Canadian Mining Institute at their regular meeting on January 13th. The subject was "Types of Steam Engines," including rotary and reciprocating types.

Willis Maclachlan, '06, is local manager at Belleville of the Trenton Electric and Water Co., and district superintendent of the Seymour Power and Electric Co.

APPLIED SCIENCE

INCORPORATED WITH

Transactions of the University of Toronto Engineering Society

DEVOTED TO THE INTERESTS OF ENGINEERING, ARCHITECTURE
AND APPLIED CHEMISTRY AT THE UNIVERSITY OF TORONTO.

Published monthly during the College year by the University of Toronto Engineering Society

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EDITORIAL

THE ANNUAL DINNER

The time and labor expended in preparation for the School dinner of 1912 were well rewarded. The response given it by guests and graduates convinced the committee that they had left few things undone. The good words of praise and admiration that followed the event were neither half-hearted nor provisional.

But the undergraduate attendance was poor, as stated elsewhere in this issue. Whether the introduction of the various class dinners, such as the 1T4 dinner, described by Mr. Adsett in the last issue of "Applied Science," dispels the desire for supporting the old established function, is creating divers opinions. Class dinners have an enormous unifying influence. The regrettable, but necessary, division of a class into its various departments, in such a manner that, if a man is not of an associative disposition, he may spend several years in the School unfamiliar with men of his own year—this undesirable factor of college life is counteracted in class dinners and class functions of a similar social nature. The idea, however, that these should displace the "School" dinner is absurd, and that the latter should not have the School man's first support is equally erroneous. The annual dinner is always on a scale impossible for a year to duplicate or approach. Influential bodies of men are swung into line and attend as a result of the impressive magnanimity of the affair. They are representative of the world's best in industrial, commercial, financial, academic or professional circles. Why are they invited and why do they come? We gain from them ideas and suggestions of inestimable value. But more important than this is the impression made upon them of the course in engineering, and the men who are in training. We enlighten them as to the status of the engineer, of the Faculty of Applied Science, and of the University. Apart from the haphazard, slow-burning, evolutionary process attending general recognition of graduate accomplishments, where the work is oftentimes forgotten ere the man has been associated with the academic training he received, what is there in this University, which, of itself, creates the publicity the institution deserves? There is nothing that approaches the efficiency of our annual dinner as a medium of publicity for the Faculty of Applied Science.

Evidently the importance of the dinner needs more ventilating in the student body. If School men are cognizant of the value to them of associating thus with their guests, chosen with so much deliberation, they would turn out to the tune of 90 p.c. instead of 30 p.c. It behooves them to be always on the lookout for opportunities to form acquaintances with the men who are their superiors in the profession, and, for that matter, in any industrial work. The resulting good to themselves and to the School is important to them, and no student should find himself graduating from this institution without acquaintance of the field before him, the men already there, and the places they are filling. If he is ceasing to assimilate this necessary information to a degree sufficient to create a desire to congregate with these men at the dinner, then he must be educated in this regard. Before next year's dinner is upon him the undergraduate must become better informed, at any rate, of the possibilities that accrue from the affair for him. He must become familiar with the names of graduates, their work and their mutual interest in the Faculty of Applied Science, together with its undergraduate body.

THE ENGINEERING SOCIETY

SCIENTIFIC MANAGEMENT MEETING

It was very regrettable to be obliged to disappoint so many who were intending to be present on Jan. 31st to hear Mr. Frank B. Gilbreth's address on "Scientific Management." Preparations were almost completed, and there was every indication of a mammoth meeting, when information arrived of Mr. Gilbreth's inability to keep his engagement, owing to distressing circumstances in New York. Announcement was later received of the death of his young daughter on the very day he would otherwise have spent in Toronto. Since his subsequent return to his official work, Mr. Gilbreth has written us of his willingness to favor us with his paper before the term closes, and in all probability a meeting will be arranged for at an early date. Every graduate in the city will receive notice of the place and date.

SECTIONAL MEETINGS, JAN. 24th.

Two sectional meetings were held on January 24th. The electricals and mechanicals combined with the chemists and miners to hear Mr. T. D. Robertson's paper on "Recent Developments in Electrical Iron Smelting," which appears in this issue. The meeting was well attended and the illustrated address exceptionally well received.

The civils listened to an address on "Trunk Sewer Design and Construction," as exemplified by Toronto's main drainage system. Mr. E. R. Gray, of Class '13, who delivered the address, last year held a position of resident engineer on a section of the trunk sewer, and has an intimate and practical knowledge of the subject.

The speaker dealt first with the problems necessitating consideration in the design of trunk and lateral sewers, in determining the amount of sewage to be provided for, and consequently the size of the sewer. These problems included a consideration of the rainfall, the area to be served by the sewer, and the amount of industrial and domestic sewage. Sewers, moreover, should be constructed to serve not only immediate, but also future needs. In gauging these latter requirements, to accurately estimate both increases of population and industrial enterprises proves no slight task.

Continuing, Mr. Gray spoke of the construction work itself. By detailed explanations, supplemented with excellent lantern slides, he vividly presented the various methods used by contractors in the prosecution of open, cut and tunnel work. In this connection the description of the "Needle Beam," seconded by an excellent slide of the same showing its application to sewer tunnelling, proved especially interesting. Different methods of handling the concrete and backfilling were also touched upon, reference being made to the different machines now in use in Toronto for trench backfilling. Other slides showed methods adopted in coping with unforseen problems, caused by soft ground and water. The lecture, which was well delivered, proved throughout most interesting, and was thoroughly appreciated.

THE INDUSTRIAL CHEMICAL CLUB

The executive of this club for 1911-12 is as follows:—

Hon. President	Dr. Ellis.
Hon. Vice-Pres.	Prof. J .Watson Bain
President	E. R. Williams
Vice-President	A. R. Bonham, '13
Secretary	A. W. Sime, '14
Treasurer	W. D. Morris, '15
3rd Year Representative	G. E. Clarkson, '13
4th Year Representative	J. Leys Gooderham

The members of the Club consist only of those graduates and undergraduates of S.P.S. who have registered in departments 5 or 6. About six or eight dinners are regularly held during the session, at which instructive papers on chemical topics are read and discussed. Excursions, also, are planned from time to time to visit such manufactories in the city, where the process is of particular interest to the chemist and chemical engineer.

The last regular dinner and meeting was a very enjoyable affair. It was held at the St. Charles Restaurant on Friday evening, Dec. 1st, with 30 members present (including 3 graduates, Messrs. R. J. Arens, C. W. Graham, and W. H. Thom). When the various business items had been duly disposed of, President E. R. Williams called on Mr. P. J. Relyea for his paper on "Retort Smelting of Zinc Ores." Two other papers were also read, viz.: "Reclaiming Zinc Scrap," by Mr. E. L. Frankel, and "Electro-thermic Reduction of Zinc Ores," by Mr. A. W. Sime. The subjects were evidently of general interest to the audience, judging by the free after discussion. Mention must also be made of a very comical chemical poem, delivered by Mr. Rogers on "Chemical Affinity." This was thoroughly enjoyed, as were the brief speeches by the "grads." The meeting was adjourned, after a profitable digression on the practical uses of "Bakelite."

THE PAST-PRESIDENTS

Some twenty-eight years ago the Engineering Society of the School of Practical Science was organized by the students, graduates, and faculty of the School of Practical Science, as a society having for its object the uniting of the student body and the discriminating of scientific knowledge.

The first president of the society was John Galbraith, M.A., at that time principal of the School of Practical Science and Professor of Engineering, now our worthy Dean. After three years under the presidency of Principal Galbraith, during which period the student body developed in student government and control, the presidency was handed over to the student body, and H. E. T. Haultain, now Professor of Mining Engineering, was elected the first student president. Since that date a president has been elected annually from among the student body, until to-day the society has nearly twenty-five past presidents, as the following list will show:

1888-9	H. E. T. HAULTAIN	
1889-90	J. A. DUFF	
1890-91	J. K. ROBINSON	
1891-92	R. W. THOMSON	
1892-93	W. A. LEA	
1893-94	J. D. SHIELDS	
1894-95	A. E. BLACKWOOD	
1895-96	G. M. CAMPBELL	
1896-97	C. F. KING	
1897-98	H. S. CARPENTER	
1898-99	W. E. H. CARTER	
1899-1900	THOS. SHANKS	
1900-01	F. W. THOROLD	F
1901-02	R. H. BARRETT	
1902-03	D. SINCLAIR	
1903-04	J. T. HAMILTON	
1904-05	E. A. JAMES	
1905-06	T. R. LOUDON	
1906-07	K. A. MACKENZIE	
1907-08	T. H. HOGG	
1908-09	R. J. MARSHALL	
1909-10	W. D. BLACK	
1910-11	A. D. CAMPBELL	

During recent years the past presidents have met frequently, but the establishment of a permanent organization, last November, as mentioned in December "Applied Science," is a move which has delighted the hearts of undergraduates, and most especially the present executive of the society. It is an organization of enthusiastic school men representing the whole field of engineering, and representing as well the graduates and the faculty. Doubtless the assistance that the Faculty of Applied Science and Engineering will receive from this new association will be great, and the Engineering Society anticipates beneficial suggestions and advice from the experiences, observations and foresight of this capable body.

THESES

The following is a list of the theses presented by the men of the fourth year:

Surveying

Plane Table Topography	T. A. McElhanney
Base Line Measurements	R. A. McLellan
Latitudes	F. V. Seibert
Town and City Planning	C. F. Elliott
Provincial Planning	E. O. Ewing
Precise Leveling and the Establishment of Bench Marks	R. E. MacBeth

Roads and Pavements

Concrete Culverts	R. K. Northey
Good Roads	L. B. Allan
Concrete Roads and Sidewalks	W. B. Davis
Highway Construction and Maintenance	W. B. Dunbar
Construction and Maintenance of Good Roads	B. W. Pick
Bitumen—Its Scientific Use	J. B. Temple
Concrete Roadways	J. E. Ratz
Street Paving	R. D. Torrance
Commoner City Pavements	W. D. Walcott
Construction of Roads	L. J. Quinlan
Concrete Culverts	F. H. McKechnie

Structural

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WHAT OUR GRADUATES ARE DOING

This section is conducted with a double object in view: first, to give the graduates professional news of each other; second, to give the undergraduates an idea of the possible fields of employment open to them in the future.

A. E. Nourse, '07, recently a fellow in the Department of Drawing, has joined the engineering staff of C. W. Noble, in the Montreal office. Mr. W. E. Taylor, '08, succeeds him on the staff of the University.

A. J. McPherson, '93, is city commissioner for Regina, Sask.

R. Smith, '98, is situated at Revelstoke, B.C., carrying on a private practice in land surveying, civil and mining engineering.

J. G. McMillan, '00, is geologist for the Temiskaming and Northern Ontario Railway.

J. L. Allan, '00, is assistant engineer for the Intercolonial Railway and is engaged on the construction of an 80 mile piece of road from Dartmouth to Deans, Nova Scotia.

H. P. Rust, '01, is principal assistant engineer to Viele, Blackwell and Buck, consulting engineers, Wall St., New York.

A. A. Wanless, '02, of Sidney Mines, N.S., is engaged as instructor, Department of Technical Education, Province of Nova Scotia.

D. L. H. Forbes, '02, has been retained by the Merrill Metallurgical Co., of San Francisco, as metallurgical engineer and representative for Ontario.

E. O. Fuce, '03, is carrying on a consulting practice and is engineer for the town of Galt.

Geo. S. Hanes, '03, is city engineer of North Vancouver, B.C.

F. G. Marriott, '03, is in the city engineer's department, Toronto, as chemist, engineer of tests, and superintendent of asphalt plant.

R. J. Benley, '04, is district engineer, irrigation office, Department of the Interior, Calgary.

W. K. Greenwood, '04, is town engineer for Orillia, Ont.

W. M. Currie, '04, is managing director of the Canada Steel Company, Limited, Hamilton.

C. J. Townsend, '04, is mechanical engineer for the Liquid Carbon Co., Chicago.

W. S. Pardoe, '04, is assistant professor of Civil Engineering, University of Pennsylvania.

J. P. Watson, '04, is engaged as locomotive draughtsman in the Motive Power Dept., C.P.R. Angus Shops, Montreal.

G. H. Ferguson, '05, is with the Commission of Conservation for Canada as assistant engineer on conservation of waterpowers.

C. E. Sisson, '05, is employed by the Canadian General Electric Co., Peterborough, as head of the transformer section of factory engineering department, the work consisting of estimating, designing and supervising.

M. H. Baker, '06, is city engineer for St. Thomas, Ont.

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Tech Applied Science.
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